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HENRY WOODWARD, F.R.S., F.G.S., F.Z.S.,

VICE-PRESIDENT OF THE GEOLOGISTS ASSOCIATION;
MEMBER OF THE AMERICAN PHILOSOPHICAL SOCIETY, PHILADELPHIA;
HONORARY MEMBER OF THE GEOLOGICAL SOCIETIES OF EDINBURGH, GLASGOW, AND NORWICH;
CORRESPONDING MEMBER OF THE GEOLOGICAL SOCIETY OF BELGIUM; OF THE NATURAL
HISTORY SOCIETY OF MONTREAL; AND OF THE LYCEUM OF
NATURAL HISTORY, NEW YORK.

ASSISTED BY

PROFESSOR JOHN MORRIS, F.G.S., &c., &c.,

AND

ROBERT ETHERIDGE, F.R.S., L. & E., F.G.S., &c.

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THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE II. VOL. III.

No. I.—JANUARY, 1876.

ORIGINAL ARTICLES.

I.—Geological Progress.

During the infancy of the "Geological Magazine" (1864–66), the new year was appropriately commenced with a short article on the Past and Present Aspects of Geology, or Geological Progress. As the Magazine is now entering upon its "teens"—the Third Volume of the Second Decade—and has attained an age in advance of any magazine having similar objects, it may not be out of place to return to the early plan, and commence the volume with some reflections upon the Science, which it is no flattery to state it has been one medium of advancing.

The increasing interest taken in the subject, is indicated by the rapid augmentation in the number of Fellows of the Geological Society of London, by the flourishing state of the Geologists' Association, and of our many local Geological Societies and Natural History Field Clubs. Another happy sign is the increase of faith and decrease of prejudice amongst the "non-scientific," in the Antiquity of the Earth and of Man. "And as time has slipped by," says Prof. Huxley, "a happy change has come over Mr. Darwin's critics. The mixture of ignorance and insolence which, at first, characterized a large proportion of the attacks with which he was assailed, is no longer the sad distinction of anti-Darwinian criticism. Instead of abusive nonsense, which merely discredited its writers, we read essays, which are, at worst, more or less intelligent and appreciative."[1]

Attention was drawn in the Magazine for August, 1865, to the losses sustained by Geologists, through the death of those who had become leaders in their several departments.

Since then our obituary notices record, amongst others, the names of Jukes, Salter, Murchison, Sedgwick, Phillips, and Lyell,—names which include the most distinguished geologists that have been, and whose careers are hardly likely to find in the future an equally brilliant counterpart. But although Jukes and Salter had only reached the full prime of life—the same cannot be said of Murchison, Sedgwick, Phillips, and Lyell: living each of them to a good old age, they saw that the foundations they had helped to lay were enduring, and that the science, which in their early days was little understood, and taught by few, had become one of the most popular.

Among these four geologists, it would seem invidious to draw comparisons. Each used his talent well—but the works of Lyell, being those in subject and in language which commanded the largest audiences, may naturally, from their wide distribution in space, be supposed to be those which will have the longest duration in time. Considering how he, more than any other man, has contributed to the advancement of Geology, partly by original observation, although more by generalization from the facts collected by others, it does seem strange that we should read in the "Edinburgh Review" for July, 1875, "that it may be affirmed that his chief characteristics were those of a retiring student," and that "the share which he had in the classification of the Tertiary rocks constitutes his principal claim to be remembered by posterity." Were it not for the high position occupied by the journal in which these statements have been made, it would be needless to criticize them. But we might well ask,—"Has the Reviewer ever 'thumbed' many pages of Lyell's Principles, that he should so ignore the work of our foremost geological teacher?"

---

[1] Quarterly Review, July, 1871; Critiques and Addresses, 1873, p. 251.

The final results of Geological inquiry, apart from their economic bearings, are to picture the successive changes in physical geography that have taken place. No one has taught this more plainly than Lyell. The science truly progresses by the help of many workers. Some take up the geology of their immediate neighbourhood, and work it out in detail. Some pay their attention to particular strata, tracing them over large areas, and working out their history. Some devote themselves to physical geology and geography, and work out problems connected with the formation of rocks and the changes of climate in past periods. Others occupy themselves in indoor study, determining the different organic remains found in the strata, or investigating the mineral structure of rocks. The record of local facts and the determination and description of fossils, afford the details necessary for the grand deductions of Geology. And to appreciate the value of details contributed in different branches of the science, to generalize upon them, or in other words to act as the architect and build up the Geological structure, has been in great part the work of Lyell. As observed in the short obituary notice of him published in the GEOLOGICAL MAGAZINE for March, 1875, "It is in the character of historian and philosophical expounder of geological thought that Lyell has achieved so much for our science."

And it is the grand results of geological research that are the most interesting not merely to the world at large, but to the geologist himself.

To know that the name of a fossil is *Thecachampsa Squankensis*, is in itself of no interest, unless we know something of the habits and allies of the creature; to know that certain rocks in Yesso belong to the "Toshibets-Karafto system of folds," is again of no interest, unless we know something of the natural history of the rocks and the conditions under which they were deposited; nor could many appreciate a "Nepheline-nosean-phonolite" unless they knew something of its physical or chemical history.

If the geologist wish, now-a-days, to increase the general stock of knowledge, he cannot study in detail rock-formation and palæongy. nor can he take up palæontology as a whole; he must devote self particularly to one or other of the great classes of animals, o plants whose remains are preserved to us in a fossil state.

he testimony of a man who would undertake to name a collec- of igneous rocks, and at the same time undertake the identifica- of a series of fossil bones, shells, corals, or other organic re- ns, would be received with a certain amount of caution.

he geologist of fifty years ago is different from the geologist of present day, and although even now there are some who have ed largely to our knowledge on many branches of geological uiry, their number is limited. Geologists should be acquainted h all branches of their science, and indeed possessed of the lead- facts in other branches of inquiry, but they cannot expect to ome authorities in more than one detailed subject. As an illus- ion, one would be surprised to hear that Prof. Ramsay was about describe a new species of fossil bird, or that Prof. Huxley had cidated the stratigraphical relations of the Devonian rocks; that f. Prestwich would report on the affinities of Graptolites, or t Mr. Etheridge had undertaken the microscopical examination igneous rocks. And yet each one would naturally be acquainted h the general results of study in each department of Geology.

The literature of the science is such a vast subject that, before ling to it, one must necessarily learn what has been previously e, and whether one is in possession of any facts not made public, of any explanations or theories not previously suggested. To dy the literature of all branches of geological and palæontological earch would indeed be a Herculean task.

It is true that our standard manuals and text-books put us in session of the leading facts and conclusions, but our magazines l journals are ever increasing the number of facts and of observers.

The study of rock-formation and of palæontology is one requiring nowledge of all that has been done, and is being done, in all parts the world.

The "Geological Record" may be looked upon as a sign of the es, the first volume being a classified list with short abstracts of papers, etc., relating to Geology, Mineralogy, and Palæontology, blished during the year 1874. Geologists will be greatly indebted Mr. Whitaker, who has edited this work, and has also prepared eral local lists of papers, etc., referring to the Geology of England d Wales.

A reference to the Geological Record will show how many, often portant, papers are little known, owing to their being published in ne local journal not readily accessible. Our Field Clubs and tural History Societies contain much valuable information that is to be thus lost sight of.

The original work of the present day must necessarily be of a re detailed nature than that of former years. As Buckland truly served, "Where the earlier geologists traversed miles, we must now- lays be content to map yards." And this is very apparent when we come to study the connexion between Palæontology and Stratigraphy. The collection of fossils, except for purely zoological purposes, is of little geological value unless the precise horizon is known, or the locality and rock described with sufficient minuteness to enable its stratigraphical position to be afterwards determined. For instance, such localities as "Devonian, Torquay;" "Devonian, Newton Bushel," are of very little geological value when the horizon and character of the rock are not indicated. The stratigraphical relations of the Devonian rocks have not yet been made out in detail; and until this is done, and it is a labour of many years, the succession of life-forms cannot be thoroughly depended upon, nor can the fossils be rightly used for identifying particular horizons in obscure tracts of ground.

Upon the geologist resident at or near spots where fossils can be obtained, the important work of collecting would devolve; and it is only necessary to mention the unrivalled private collections of Mr. J. E. Lee, of Torquay, or Mr. Vicary, of Exeter, to show how much may be done in this way. Nor should we fail to estimate highly the palæontological labours of Phillips, Etheridge, T. M. Hall, and others, who have by their combined work rendered our knowledge of the Devonian fauna very complete; but, (as in the work of Phillips), the precise horizons of all the fossils which swell our lists are not indicated, nor can they be determined until the stratigraphical relations of the rocks are made out in detail in West Somerset, Devon, and Cornwall.

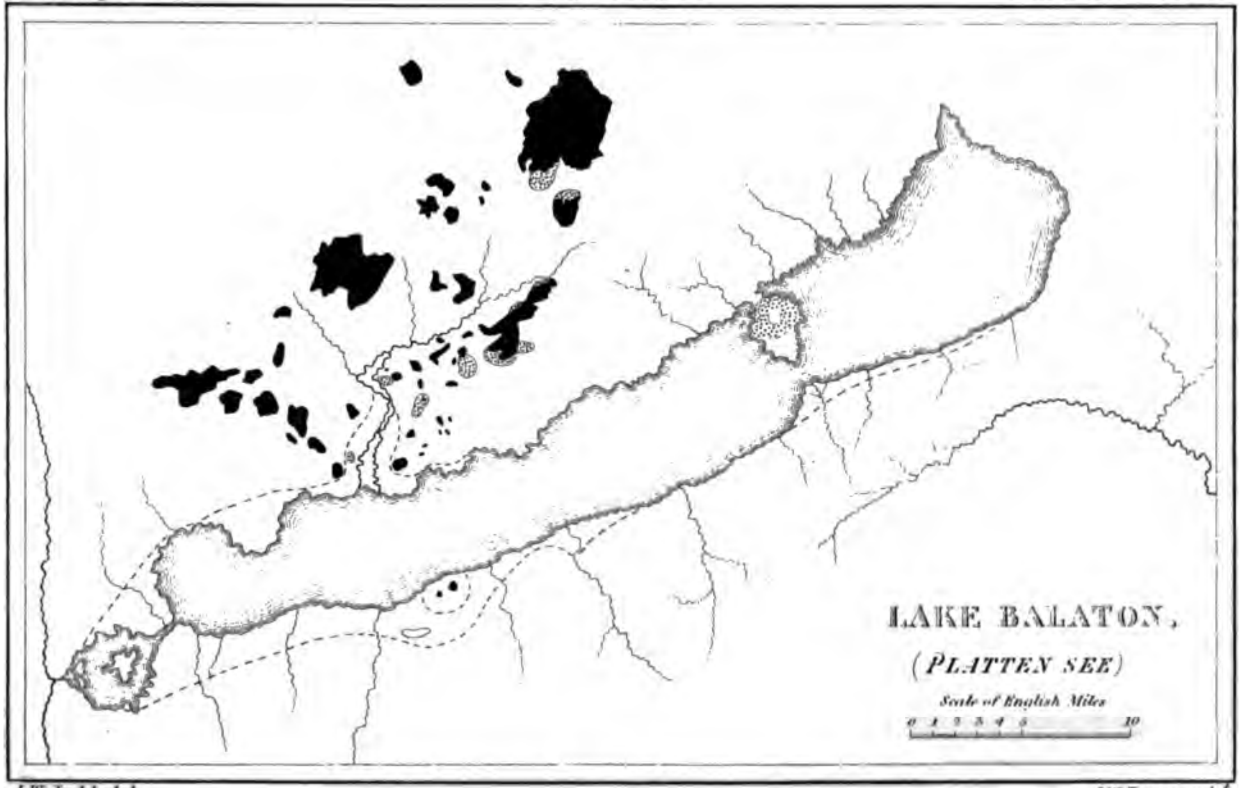
Time, save to the professional geologist or man of fortune, is frequently very limited, at any rate for field-work, but for this reason the observations made on geological excursions and holiday trips are by no means to be despised. And in this direction the Geologists' Association deserves the highest praise for carrying out such an excellent annual series of both long and short geological excursions.

There are many points needing corroboration, and many facts to be gathered, in which a month or six weeks' holiday may be profitably spent, and even far shorter periods. But geological excursions, when several meet together, are very often, and rightly, rather times of relaxation than of actual work. Geologists, whose special studies perhaps lie in different directions, meet: the actual details of sections visited are in themselves perhaps interesting to but a few; and hence on field-excursions, there are many individuals who come under the designation of "bread and cheese naturalists." They come out for relaxation; and fresh air and novel scenes exhilarate, and lunch is perhaps particularly enjoyed.

In these days, when so much is said about mental strain and the hurry of life in the struggle for existence, the relaxation of natural history excursions by field clubs is rather to be commended than otherwise.

And, after all, the "high-water mark" of thought (as Prof. Huxley puts it) consists in dealing with educational, scientific, and philosophical subjects in a broad, general, and interesting way, so that one may get out of the groove in which one's special work lies, and afford time for the consideration of subjects the outcome of special work in all departments of Science.

Geol. Mag. 1876. NEW SERIES. Decade II. Vol. III. Pl. I.



J.W. Judd, del. J.W. Lowry, sculpt.

- - - - - Former limits of the Lake. ■ Basaltic Lavas. ▨ Basaltic Tuffs.

II.—CONTRIBUTIONS TO THE STUDY OF VOLCANOS.

By JOHN W. JUDD, F.G.S.

ON THE ORIGIN OF LAKE BALATON IN HUNGARY.

(PLATE I.)

IN our last chapter[1] we referred to the frequency of the occurrence of lakes in districts which contain volcanos that are still active or have only recently become extinct.[2] In connexion with this subject, we must also call attention to the interesting circumstance that, wherever the geologist finds evidence of the former action of subaerial volcanos, there he almost invariably detects proofs also, that numerous lakes have been formed and successively filled up with sediments. Very strikingly is this fact illustrated among the great series of volcanic rocks, which, during a great portion of the Tertiary period, were being erupted in Central and Southern Europe; and which form an almost complete girdle surrounding, but lying at a considerable distance from, the great central masses of the Alps. We have in these districts the most unmistakable palæontological evidence that the periods of violent volcanic activity were also characterized by the repeated formation and filling up of lake-basins.

We have already shown how a study of the features presented

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[1] See GEOL. MAG. 1875, Decade II. Vol. II. p. 349.

[2] It has been suggested to me by my friend Mr. Scrope that this fact of the very constant connexion between volcanic action and the formation of lake-basins would be brought out very clearly and impressively by an estimate of the number of lakes which at present exist in the Auvergne, together with those which have in very recent times been filled up with alluvium. The large map of that part of the Auvergne included within the Department of the Puy de Dôme, prepared by the Abbé Le Coq, lends itself admirably to such a purpose, and I have obtained from it the following results. The area of the Department of the Puy de Dôme is only a little greater than that of the English county of Lincoln, yet its surface is studded over with the relics of no less than 276 lakes and lakelets. These may be classified as follows:

1. Crater lakes, either still existing or filled up with sediments, and clearly formed by explosive action	18
2. Lakes formed by the arrest of drainage in a valley by the flowing of a lava-stream into it, or by the throwing up of volcanic cones in its course	3
3. Lakes lying among the volcanic rocks and due either to the irregular accumulation of volcanic materials, to local subsidences, and other changes of level	81
4. Lakes lying in similar depressions among the rocks of the old granitic plateau, generally in the lines of drainage, and owing their formation to local changes of level in this formerly violently disturbed district	174
Total . .	276

In this estimate I have included only the smaller examples of lakes of very recent date. The exact limits of the larger ones formed in the great river-valleys of the district it is now very difficult to define; and the patches of lacustrine sediment, filling innumerable depressions both of large and small size, of older date, are greatly obscured by later formed volcanic products or have been to a very great extent removed by denudation. I need only add that, as Le Coq well shows, the district of the Auvergne could never have been the seat of powerful glacial erosion, although the perpetual snow which may have clad the higher parts of the district during the Glacial Period may have contributed to the *preservation*, though not to the *formation*, of the lakes in question, in the manner pointed out in this paper.

by the great circular lakes of the Italian peninsula leads us to the inevitable conclusion that they, in common with the numerous similar ones of smaller dimensions, owe their origin to the *direct explosive action* of volcanic forces,—and that they occupy, in fact, the bottoms of vast craters which have been formed by this agency.

But, as we have already remarked, it is not by such direct explosive action alone that the volcanic forces are capable of originating those depressions in the surface of the land which constitute lake-basins. Sometimes an ordinary river-valley may have a part of its course dammed up, either by the flowing of a stream of lava across it or by the throwing up of volcanic cones in its midst. And still more striking are the effects produced on the system of drainage in a district by the subterranean movements which so constantly precede, accompany, and follow the outburst of volcanic forces. By this agency true rock-basins, often of vast dimensions, are formed,—sometimes by local subsidence, at others in consequence of inequalities of movement along a line of river-valley.

It would perhaps be impossible to cite any clearer or more striking illustration of the formation of a rock-basin, capable of containing a lake, by the subterranean action of volcanic forces, than that of Lake Balaton (or the Platten See, as it is called by the Germans) in Hungary.

Among all the beautiful lakes which at the present time surround the Alpine system, there is none which equals in size Lake Balaton. It has a length of about 50 miles, and a breadth varying from 3 to 10 miles, its area being no less than 420 square miles. Its depth, however, unlike that of many of the Alpine lakes, is not very considerable, averaging only between 30 and 40 feet. Lake Balaton is, nevertheless, a magnificent sheet of water, and in picturesque beauty is scarcely, if at all, inferior to any of the more famous lakes of Southern Europe.

In certain of its features, however, Lake Balaton presents interesting points of contrast with the Alpine lakes, and to these it will be instructive to refer. It does not occupy, like them, a depression in one of the great valleys radiating from the Alps, nor has it, indeed, any visible natural outlet. A number of more or less considerable streams flow into it; but until the Roman emperor Galerius constructed a canal between it and the Sio, a tributary of the Danube, the waters of the lake had no communication with that or any other river. Nevertheless, these waters are almost perfectly fresh, and exhibit only the faintest trace of saline characters.

It is clear to any one who examines Lake Balaton that it occupies a true rock-basin—that is, an actual depression in the surface of the land—and that its waters are not merely dammed up by superficial accumulations. The rocks which inclose it are, on its northern side, of Triassic and Rhætic age, and, on its southern, of older Neogene (Miocene) date—the latter being about the equivalents in time of the Molasse of Switzerland, which forms the shores of a great part of the Lake of Geneva and of so many other Alpine lakes. On all sides, but at different distances from it, the lake is encircled by hills of considerable but varying elevation, the bold spurs of the Bakony Wald coming down to its northern shores; while the alluvial flats of great extent on its banks, and the beaches at some elevation above its surface, testify to the former considerably greater extent of the lake.

Let us now inquire what evidence is afforded to the geologist, who studies its features, concerning the mode of origin of the great depression in the earth's surface in which Lake Balaton lies.

With respect to that agency which is so confidently appealed to by several Scotch geologists as having originated the greater portion of the rock-basins, in which lakes lie,—namely, the alleged power of a glacier to *excavate* a depression in the earth's surface,—it will only be necessary to mention certain facts concerning the position and features of Lake Balaton, to demonstrate the utter futility, at all events in this case, of any such mode of explanation. Not only does the district exhibit none of the usual evidences of powerful ice-erosion, but it is quite impossible to conceive how such action could have taken place here. The hills of the Bakony Wald, lying on the north of the lake, are certainly not of sufficient extent and elevation to have constituted the gathering ground of a great glacier, and the only possible source of such an agent must therefore be sought in the more distant Alps. Assuming for one moment that there existed during the Glacial Period an ice-river of sufficient dimensions to have extended from the Eastern Alps to Lake Balaton (though of this no proof has, so far as I am aware, been ever adduced)—such a glacier would naturally have followed the valley of the Mur or that of the Raab, in neither of which do great lakes exist, and could not have originated Lake Balaton, which lies on the plateau separating the basins of these two rivers. For an Alpine glacier to have excavated the bed of Lake Balaton, it must have been able with a very slight initial descent—the Eastern spurs of the Alps having a comparatively small elevation—to traverse a nearly level plain 100 miles in width, to have then surmounted a group of hills some 30 miles broad and from 1000 to 1200 feet in elevation, and after all this expenditure of force to have retained sufficient energy to dig in the midst of solid rocks a basin of vast extent. In short, Lake Balaton lies exactly in that position which is of all others the least favourable that it is possible to conceive for the action of the supposed excavating power of a glacier from the Eastern Alps; while the points at which the erosive action of such a glacier would naturally operate with greatest effect exhibit no traces whatever of the formation of rock-basins.

But in the case of Lake Balaton there is opportunely furnished to the geologist a means of applying to the theory of ice-erosion a *crucial test.*

Right in the midst of the lake, and almost dividing it into two portions, rises the peninsula (once an island) of Tihany; this is a mass of considerable elevation, composed for the most part of loose basaltic tuffs, and evidently constituting the relics of an old volcanic cone.

Now it is quite impossible that a glacier, which had sufficient excavating power to produce that great depression in the solid rocks in which Lake Balaton lies, could nevertheless have left standing right in its course such a mass of comparatively soft tuffs as constitutes the peninsula of Tihany. And it must therefore be clear to every one that, if these volcanic outbursts which formed this mass can be shown to be of no later date than the Glacial Epoch, the basin of Lake Balaton could not possibly have had its origin in ice-action during that period.

In determining the geological age of the tuffs of Tihany we have the most unmistakable evidence in the fossils which they contain. These prove conclusively that the volcanic outbursts by which they were formed took place during the deposition of the 'Congeria Schichten'—which are placed by Karl Mayer on approximately the same horizon as our Coralline Crag. That the basaltic lavas and tuffs of the Bakony Wald were formed long prior to the Glacial Period, there is not, indeed, the slightest room for doubting: and this conclusion is quite in harmony with the appearances of very extensive denudation which these volcanic rocks present:—the lava-streams being reduced to isolated plateaux, the tuffs in great part swept away, and the plugs of basalt that have filled the throats of the old volcanos, in many cases left standing above the rocks they have penetrated.

Dismissing then on these conclusive grounds the theory of glacier-erosion as certainly inapplicable to the case of Lake Balaton, let us inquire if the examination of the district does not suggest any other mode of origin for it. Such, we think, every geologist will at once recognize as indicated by the volcanic outbursts that have taken place, not only on its northern and southern shores, but also in the midst of its bed. The volcanic district of the Bakony Wald and Lake Balaton, which is illustrated in our sketch-map, Plate I. (the materials of which are derived from the Geological Maps of the Vienna Reichsanstalt and those of the Geological Institute of Hungary), is a portion only of a linear series of later Tertiary volcanos, which stretches south-westward from the Matra of Northern Hungary to the Danube, being prolonged on the opposite side of that river by the trachytic outbursts lying north-east of Stuhlweissenburg, and beyond the Bakony Wald in the opposite direction through Styria to the neighbourhood of Gleichenberg. It is impossible to doubt that the peculiar arrangement of this series of contemporaneous volcanic outbursts points to the existence of a line of fissure in the earth's crust at the time of their occurrence; and it is a very significant circumstance that the longer axis of the great depression in which Lake Balaton lies exactly coincides with this line of volcanic action.

We have already had occasion to refer in these chapters to the local subsidence which, as demonstrated by Darwin, so frequently follows the cessation or accompanies the decline of volcanic activity in a district; and which is so admirably illustrated by the Lipari Islands and Santorin among recent volcanos, and by that of Mull

g those of more ancient date. In such a subsidence, therefore,
ecognize a competent and obvious cause of the production of
rock-basin occupied by Lake Balaton. And the fact of such
dence is confirmed, as in the analogous case of the island of
, by the exceptional state of preservation of the old volcano
ihany.

'e thus see that an examination of the phenomena presented by
largest of all the lakes in southern Europe leads us to ascribe
rigin to the subterranean movements that have accompanied
anic action. It is interesting to notice the circumstance that by
he largest lake in our own islands exhibits the clearest proofs of
ng been formed by the same agency. Some years ago, while
ying the basaltic rocks of Antrim, I was strongly impressed by
conviction that Lough Neagh must clearly have been formed by
idence taking place subsequently to the great development of
anic activity in the district; and this view is abundantly con-
ed, and indeed placed beyond the possibility of doubt, by the
able observations made by Mr. E. T. Hardman, of the Geological
vey of Ireland, during his detailed examination of the district.
communication laid before the British Association in 1874, Mr.
dman shows conclusively that Lough Neagh (which must origin-
have had an area nearly twice as great as at present) existed
re the Glacial Epoch; and that a series of post-Miocene disloca-
s, which he has traced during his survey, would lead to a sub-
nce of the tract occupied by the lake.

'hat the very remarkable valley of the Jordan occupied by the
s of Merom, Tiberias and Asphaltites (Dead Sea), the latter of
ch is 1300 feet below the Mediterranean, is an ordinary river,
ey, which once terminated in the Gulf of Akabah, but in the line
which great depression has taken place, seems now to be clearly
ved by the officers who have conducted the Ordnance Survey of
estine. And there appear to be grounds for connecting this great
ression, which was once occupied by a single vast lake, with
anic action in the district.

'he three examples we have cited represent very fairly the three
cipal types of lake-basins which exist upon the earth—Balaton
g an example of a vast but shallow depression without natural
et,—Lough Neagh a smaller but deeper lake lying in a system
lrainage,—and the Jordan gorge a depression in a line of river-
ey, the bottom of which now lies far below the sea-level.

ut in pursuing this line of reasoning we may perhaps go one
further. The interesting accounts that have recently come to
d of the explorations of Mr. Stanley in equatorial Africa suggest
probability that the noble lake of the Victoria Nyanza (which
fair to prove a rival in size to Lake Superior in North America,
therefore to be the largest sheet of fresh-water in the world)[1] may

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[1] There is still some doubt remaining as to the dimensions of the Victoria Nyanza.
Ir. Stanley's map represents the true positions of points on its shores, then the
would certainly be larger than Lake Superior. If, however, Captain Speke's
minations of positions be *accepted as the* more accurate, as Mr. Ravenstein
eates, then the African lake would be about one sixth smaller than the American.

also lie in a basin formed by volcanic subsidence. It is now apparent that this lake is no mere marsh, or collection of lagoons, as soundings *near its shores*, which are often exceedingly bold and even mountainous in character, have been found to indicate depths up to 275 feet. The fact of the existence of this and the neighbouring lakes *immediately under the equator* will be of course accepted as proving that they, equally with Lough Neagh and Lake Balaton, could not have been formed by the agency of ice during the glacial period. On the other hand, the frequent mention of basaltic rocks as occurring on its islands and shores, and the report of the existence of a number of active volcanos in its proximity, at least suggest that it may owe its origin to the action of the same causes which have formed the lakes in question. But for the final settlement of this question we must await the arrival of fuller details concerning this very interesting lake district of Central Africa.

We think that the foregoing remarks will be accepted by all as showing that rock-basins—even those of the very largest dimensions—may have had their origin in those changes of level resulting from the subterranean movements which have accompanied volcanic action,—and that, as a matter of fact, the largest lakes in the British Islands and in the Alpine regions of Europe, respectively, and not improbably the vast sheets of water in Central Africa also, have been so formed, and could not possibly be the result of glacier-erosion.

It would of course be very easy to multiply to almost any extent the examples of lakes which, like those of Van, Urumiah, etc., in the district south of the Caucasus, are clearly connected with the outburst of volcanic forces; or of others, like those of Nicaragua, Managua, Maracaybo, and Titicaca, etc., in the Equatorial part of the American continent, which no one can dream of as having been formed by the action of glaciers.

It may here, however, be necessary to point out that our argument lends no support whatever to the inference that, in those districts where the action of *volcanic* forces cannot be traced, lake-basins must be the result of other than subterranean agencies. On the contrary, we maintain that movements, precisely similar in character to those which take place in volcanic districts, are constantly occurring on every part of the earth's surface. It is probable, indeed, that the movements which are connected with volcanic activity are often of a more sudden and violent character than those which take place in non-volcanic districts, and that in consequence of this their effects are more strikingly manifest to us. But to suppose that the *permanent effects* produced in the case of the former are necessarily greater than in that of the latter, would be as unphilosophical as for a geologist to ascribe to sudden floods (the effects of which strike the most casual observer) a greater share in the excavation of valleys than to the unobtrusive but constant actions of atmospheric waste and ordinary transport by streams.

If we can demonstrate, in the first place, that in those districts *where the effects of subterranean movement are most readily traced (namely volcanic areas)* rock-basins have certainly been produced by *this agency; and,* in the second place, that movements similar in character and equal in extent occur in other districts, though in a manner which renders their effects less capable of detection by us,—are we not justified in accepting such movements as capable of explaining the formation of lake-basins in all cases, rather than in having recourse to a purely hypothetical cause?

And if this mode of viewing the subject be a legitimate one, what reason can be adduced for doubting that those great disturbing forces—which, during and subsequently to the Oligocene and Miocene periods, have given rise to such startling results in the contortion and even in the inversion of the rocks of the Alps, but which at the same time have produced only inconsiderable effects in the areas immediately surrounding them—*must* have originated, in different parts of the great lines of drainage descending from those mountains, such inequalities of movement as could not fail to result in the formation of lake-basins? Now it is a most striking and significant circumstance that a careful study of the deposits that were formed *immediately around the Alpine System* during the periods of most violent movement leads to the conclusion that, near the limits of the disturbed and unaffected areas, lakes were constantly being formed and filled up with sediments. Nor have we the smallest grounds for inferring that such movements have altogether ceased, and could have played no part in the origination of the existing lakes in similar positions; but, on the contrary, even the stoutest advocates of the glacial origin of these lakes admit that considerable movements must have taken place, both in the Alps and elsewhere, during and subsequently to the Glacial Period.

This is the view of the mode of origin of the great Alpine lakes which was maintained by the late Sir Charles Lyell, and which has been supported by the critical examination of a number of special examples by the Rev. T. G. Bonney. And the same opinion concerning the formation of these lakes is held by the distinguished geologists of Germany, Switzerland, France and Italy, who during the last thirty years have made such splendid additions to our knowledge of Alpine geology; with but one solitary exception, we believe, all the geologists who have especially devoted themselves to the study of these regions have rejected the hypothesis of the glacier-erosion of the lake-basins as both unnecessary and inadequate.

Of the various facts which have been adduced as lending support to the doctrine of the erosion of lake-basins by ice, the only one which can be said to afford a presumption in its favour is the abundance of lakes in districts which have been recently subjected to glacial erosion. But this fact, as was shown by the late Sir Charles Lyell, is capable of another and very simple explanation, without calling in the agency of so problematical a cause as the excavating power of ice. A very large proportion of the lakes and lakelets, found in glaciated districts, are in reality formed through the arrest of drainage by the peculiar and often seemingly capricious modes of accumulation of moraine matter. The smaller number of true rock-basins which remain, after eliminating the moraine lakes, appear indeed to owe *their existence also to the* action of glaciers, but in a very different manner from that maintained by the advocates of the doctrine of ice-erosion, or even from that suggested by M. de Mortillet.

In considering this question, it must always be borne in mind how rapidly the effects of subterranean forces on the drainage of a district are masked and concealed by the action of denuding causes. As we sail over the great Alpine lakes, we are constantly impressed by the fact that, even in the case of those of most profound depth, every tiny streamlet that descends from the surrounding mountains is pushing a delta boldly into its waters, while the larger streams have often produced alluvial flats of enormous extent, that have evidently been reclaimed from the area of the lake. To the eye of a geologist, indeed, almost every lake may be said to be *visibly filling up*; and the whole Alpine System is encircled by innumerable *extinct lakes*, belonging to various geological periods. The effects produced by local subterranean movements in the line of a river-valley—whether in creating an increased fall, and thus originating rapids and waterfalls, or in arresting the drainage at certain points, and thus forming lakes—must be regarded as bringing about a condition of *unstable equilibrium* in the valley; while the erosive and transporting action of the stream is continually tending to remove the temporary derangements in the system of drainage by the cutting back and levelling of the precipices over which rapids and cascades descend, and by filling up the beds of lakes or cutting through the dams that retain them. In those valleys, indeed, wherein the action of denuding forces more than counterbalances that of subterranean movement, the formation of rapids and of cascades on the one hand, and of lakes on the other, will be prevented.

In this admirably adjusted system of mutually antagonistic agencies —those namely of surface erosion and subterranean movement—the occurrence of a period characterized by glacial conditions will produce an interruption, which must be attended with very marked though temporary effects. The depressions which under ordinary circumstances would form the beds of lakes, and then rapidly be filled with sediments, would probably be occupied by inert masses of ice, over which the glaciers would flow in just the same manner as the waters of some of the existing Alpine rivers pass over the surface of the lakes that lie in their course, without producing any appreciable effect on the great mass of cold water that occupies their profounder abysses. This temporary arrest of the compensating effects of river action in a valley—while the antagonistic agent, subterranean movement, remained unaffected—would of course result in the formation and preservation of a greater number of lake-basins on the one hand, and of abrupt slopes on the other, than could be originated under ordinary conditions.

These considerations, taken in connexion with the frequency of the arrest of drainage by moraine matter, enable us to understand that frequency of lakes and tarns in glaciated districts, to which such importance has been attached by the advocates of the theory of ice-*erosion.*[1] But they also afford an equally simple explanation of certain facts, which are altogether inexplicable by and opposed to the theory of the excavation of rock-basins by ice—namely, the frequent absence of lakes in certain other glaciated regions and in situations where, according to that theory, the conditions were most favourable for their production. If, as we maintain, the formation and preservation of numerous lake-basins in a district is due to a favourable coincidence of subterranean movement with the suspension of the obliterating effects of river denudation through the occurrence of glacial conditions at the surface, then the abundance of such lakes in some glaciated regions and their paucity in others are alike accounted for.

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[1] *Mr. Scrope has called* my attention to the interesting circumstance that in both

It is, however, impossible to conceal from ourselves that the real obstacle to the reception of so simple an explanation of the formation of lake-basins, as that afforded by local changes of level due to differential subterranean movements along lines of drainage, and the consequent appeal to the hypothetical agency of the excavating power of ice, is the strange assumption that the production of the features of the earth's surface is entirely due to the action of denuding agents, and that subterranean forces have played no part whatever in the matter. We cannot but regard this doctrine—so boldly advanced by several modern writers on geology—as opposed to the fundamental and best established principles of the science, and as being not less mischievous in its tendencies, than it is unsupported by facts.

That differential movements of the most striking character have taken place in the earth's crust during every geological period, no one who examines the admirable detailed maps of the Geological Survey of the United Kingdom, and studies the effects produced by the numerous *faults* indicated upon them, can for one moment doubt. And yet every practical geological surveyor will readily admit that the dislocations of the strata, which he is able to detect, bear probably only a small proportion to those which actually exist. This is shown by the fact that while in formations exhibiting rapid alternations of thin beds, like the Coal Measures or the Oolites, in which faults are easily detected, they are represented as exceedingly abundant, in others, consisting of uniform masses like Mountain Limestone, Lias Clay or Chalk, where it is difficult to trace their effects, but very few are indicated. But even where no actual fractures of the strata occur, undulations and foldings of various degrees of curvature bear witness to the continual action of subterranean forces. And that the effects of these were felt at the surface is amply demonstrated by peculiarities in the mode of accumulation of the various sediments, which, as Darwin has so well shown, must ever be dependent on the rate of subsidence. Nor have we the smallest grounds for believing that these subterranean movements and the effects produced by them at the surface are one whit less powerful at the present time than during former geological periods. In proof of this we need only point to the numerous facts that have been accumulated, especially by Lyell and Darwin, show-

the Scandinavian and North American regions, which exhibit such a vast number of lakes, we have unmistakable *proofs that* considerable movements of the surface of *the land have been going on in comparatively* recent times.

ing that the present surface of the earth is subject to slow but powerful movements, sometimes wide-spread in their operation, but at others exceedingly local. The modes of reasoning by which geologists have arrived at these conclusions concerning the movements of the earth's surface are not less cogent and convincing than those which they adduce in support of their views concerning the effects of denuding agents. And it is quite possible to admit *to their fullest extent* the important part played by atmospheric waste in the moulding of the features of the earth's surface, without persistently shutting our eyes to the effects of those subterranean forces, concerning the operation of which we have equally convincing evidence.

The only mode of escaping from this mode of reasoning is by denying that local and differential movements, such as have so constantly produced bending and fracture in the strata, are still at work on the earth's crust; or, as Mr. James Geikie appears to do,[1] to assume that they can produce no effects at the surface. That faults do not produce "lines of cliffs" at the surface (except perhaps under peculiar and exceptional conditions) we are ready to admit—for the denuding forces are constantly at work masking and modifying the effects of the subterranean; and both are equally slow and all but imperceptible in their modes of action during the limited periods of human observation. But for the conversion of an ordinary river-valley in part of its course into a lake-basin, it is by no means necessary that any movement of so great and violent a character as to produce a fault in the subjacent rocks should take place. Any one who will examine the longitudinal section of a lake-basin *accurately drawn to scale,* such, for instance, as the instructive examples given by Professor Ramsay, must admit that an almost imperceptible curvature of the strata, to the extent of two or three degrees only, will suffice to produce even the deepest known lakes.

That lines of flexure and fracture must have had much to do in the original determination of the lines of drainage of a district, it is impossible to doubt. And that periods of violent movement in a district may have resulted in important modifications and vast alterations in its system of drainage, few will hesitate to admit. Where too, as in the case of Lough Neagh, the detailed mapping of the district by a competent observer brings to light faults, the position, effects, and age of which are exactly such as would result in the surface movements necessary to produce the rock-basin in question, we are surely justified in inferring a connexion between the two sets of phenomena. But it by no means follows that where we are unable to detect a fault crossing the line of valley or a synclinal fold in its course, there subterranean movement could have had no part in producing a lake-basin in it. The amount of vertical movement necessary to originate even the deepest known lake-basins bears so small a proportion to the length of the valleys in which they lie that we do not hesitate to affirm that their effects upon the subjacent strata could not, save under exceptionally favourable conditions, be detected by the most experienced geological surveyors.

It is only by those who ignore altogether the operation of subternean forces, in directing, controlling and modifying the effects produced by denuding agencies, that any difficulty has ever been experienced in accounting for the formation of lakes, or that the necessity is felt for assuming that *rivers of ice* possess a power, which it is on all hands admitted does not belong to *rivers of water* —that of excavating great basin-shaped depressions in their course. To those who believe that—alike in the present and during all former geological periods—the subterranean and subaerial agencies have been in unceasing action, side by side, and that the present features of the earth's surface are the result of the constant mutual interaction of these two classes of forces—the formation of rock-basins, far from being, as is asserted, an *abnormal* phenomenon, is one of the necessary consequences of the antagonistic agencies which we can demonstrate to be operating on the surface of our planet. If it be granted, in the first place, that meteoric agencies have the power of producing great lines of drainage (valleys) on the earth's surface—and, in the second place, that different portions of such lines of drainage may be subjected to unequal vertical movement—and of the truth of both these postulates we can produce equally unmistakable and convincing evidence—then it follows, inevitably, that cascades or rapids on the one hand, and lake-basins on the other—the results of converse relations of the two sets of forces—*must be* from time to time produced in these lines of drainage. And if all the existing lake-basins are to be assumed to have been produced by ice-erosion, we may surely be justified in asking—What has become of those which must have resulted from the action of the obvious causes to which we have just referred?

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[1] "The Great Ice Age," page 289.

To sum up the argument of the present chapter—We have demonstrated that the basins of the largest lakes in our own islands, in the Alpine regions of Europe, and in equatorial Africa, respectively, *could not possibly* have been formed by the supposed excavating power of ice. We have also shown that in each of these cases there is the strongest ground for believing the districts in question to have been subjected to powerful subterranean movement; and that these were quite competent to produce the depressions in question.

But if it can be proved that in the case of lakes which happen to preserve evidences of the manner and date of their origin, the ordinary operations of denuding and subterranean forces are quite competent for their production—even when the lakes are of the very largest dimensions—where is the necessity for calling in the aid of a new and problematical agency to account for the formation of the smaller examples?

For ourselves, we must add—in the face of the strenuous efforts which have recently been made to resuscitate the doctrine of the erosion of lake-basins by ice—that an attentive study of the lakes of both the Scottish Highlands and of the Alps (districts which have been so confidently appealed to as affording the strongest support to the theory) has only served to confirm our conviction in the justice of the conclusion, on this subject, that has been arrived at by all except an inconsiderable minority of geologists—namely, that the agency in question *is as unnecessary as it is* hypothetical.

III.—SKETCH OF THE GEOLOGY OF ICE SOUND AND BELL SOUND, SPITZBERGEN.

By Professor A. E. NORDENSKIÖLD, of Stockholm.

ICE and Bell Sounds are two large fiords opening out on the west coast of Spitzbergen, which cut deep into the country, both in an easterly direction towards Stor Fiord, and in a northerly direction towards the south part of Wijde Bay. The shores of the Sounds are for the most part occupied by high mountains, precipitous towards the sea, nearly free from snow during the summer, whose sides, being bare of vegetation, offer the observer an uncommonly favourable opportunity for studying the geological structure of the rocks. Within an exceedingly limited space one meets here with a succession of strata belonging to a great many different geological periods, and rich in fossils, both of the vegetable and animal kingdom. The geographical situation, too, confers on the fossil organisms met with in these regions an altogether special importance in relation to the questions of the former climate of the Polar countries, of the former distribution of land on the globe, and others of the weightiest problems of geology. These circumstances render this region, now so neglected, one of the most interesting spots in a geological point of view on the globe; and it was on this account that all the Swedish Polar Expeditions remained for a longer or shorter time in these Sounds, and examined their geology more thoroughly than has perhaps been done in the case of any other Polar country. A brief statement of the results thus obtained forms the subject of the present paper.

An ideal section of Spitzbergen from east to west presents an appearance approximating to that shown in the accompanying figure. (Fig. 1.)

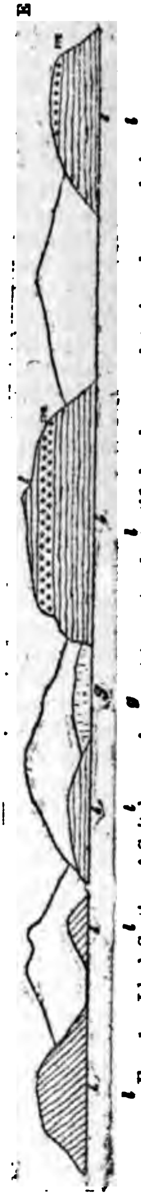

FIG. 1.—Ideal Section of Spitzbergen from east to west. *l.* stratified rocks; *m.* plutonic rocks; *g.* glaciers.

The west coast from South Cape to King's Bay is formed of sedimentary strata standing vertically. Farther into the interior, as far as to the east side of Stor Fiord, the strata, with some local exceptions, become more or less horizontal, although it is just in these regions that extensive beds and masses of unstratified rocks occur in greatest abundance. The dip and contortion of the strata it is evident do not stand in any immediate connexion with the outburst of plutonic rocks. The numerous fiords also in most cases are nearly at right angles to the direction of the strata at the coast, which shows that these basins were not formed in connexion with those changes of level which disturbed the original horizontal lie of the strata. If we carefully examine the shores of the fiords, the way in which the channels referred to branch out towards the interior, to terminate abruptly in an old glacier moraine, or with a glacier still in action, we see clearly that the common theory of the formation of valleys, that is to say, the supposition that valleys have been formed in the Plutonic way through a sinking of the earth's strata, is not applicable here, but that the fiords of Spitzbergen, the water-filled valley-depressions in question, were formed after the close of the Miocene period through the denuding action of ice-streams from an inland ice-field, which probably was considerably more extensive than that which now occupies the interior of Spitzbergen.

Although it is probable that Spitzbergen was not covered by glaciers before the end of the Miocene period, it can be proved that on that part of the world also glaciers occupied a greater extent in former times than now. If we examine the rocks at the sides of the fiords and the small islands which environ the coast itself, numerous proofs of this are to be found. The rocks in these regions are in most cases indeed so split up by frost that the original surface has been completely destroyed, and generally the rock is too loose and easily crumbled down to permit any glacial scratches to continue for a length of time upon a surface exposed to the air. But sometimes there occur yet harder rocks, *gneiss*, *quartzite*, *diabase*, etc., which are better adapted to resist the destructive action of the atmosphere; and on such rocks, when they lie near the water's edge, there are nearly always found, on a close examination, beautiful striæ and furrows, *which run in the same direction as the fiord.* From this we draw the conclusion that the now existing fiord was formerly filled with a glacier or ice-stream, and that the glaciers on the west coast at a former period extended at least to that garland of rocks and small islands by which the land is now environed. Judging from the absence of deep fiords on the east coast of Spitzbergen, and the shallowness of the sea between Spitzbergen and Nova Zembla, we infer that the inland mer de glace in former times extended considerably further in that direction. *Probably during the Glacial Period the west coast of Spitzbergen was the west coast, not merely of a large island, but of a considerable Arctic continent, which towards the south was connected with Scandinavia, and towards the east with continental Siberia.*

I have never seen any striated rocks at a height exceeding 1000 feet upon the mountains of West Spitzbergen. The reason probably is the destructive action of frost upon the rock-surface.

But it is worthy of notice that while the gneiss and granite mountains nearly 1800 feet high, on Parry's, Phipps's, Marten's, and Castren's Islands, all lying on the north coast of North East Land, upon one side, chiefly the south, exhibit rounded forms, which clearly show that the mountains were completely covered by glaciers; the rocks of the same varieties on the north-west corner of Spitzbergen, on the contrary, do not give any certain evidence of having been entirely covered by ice.

I cannot adduce any conclusive proof that the glaciers are *continuously* receding. On the contrary, judging by the last centuries' experience, we are inclined to suppose that they are again advancing. As instances of this we may adduce

Frithiof's Glacier in Bell Sound.—In my sketch of the geology of Spitzbergen I give the following account of this glacier in 1858 and 1864:

> "On the North coast of Bell Sound, directly to the East of the large island which separates Van Mijen's Bay from the main sound, there existed, only a few years ago, one of the best harbours of Spitzbergen. The whalers on their way from the North coast to Stor Fiord used often to anchor at this harbour in order to hunt reindeer in the neighbouring fertile valleys; and this too was one of the first places visited by Professor Torell's expedition in 1858. During this expedition I explored the surrounding country in all directions, so that on revisiting the place in 1864 I was able clearly to call to mind its former aspect. The shores of the harbour still in 1858 consisted of a broad strip of muddy land intersected by brooks, bounded on the West by high mountains, and on the North-east by a hill, on which an old cross had been erected over a grave. More to the East stretched, as far as Coal Mount, a marshy low flat traversed by a considerable stream. Directly above the banks of mire and gravel, composing the strip of muddy land which formed the shores of the harbour, gradually commenced a low but broad glacier (the Frithiof Glacier), which did not, as is usually the case with the glaciers of Spitzbergen, terminate abruptly with a break, and which was consequently considered by us as a *receding glacier*. In the banks of mire were found remains of various marine shells still covered with their epidermis, from which Torell suspected that these mounds of mud were not moraines, but had been recently forced upwards from the bottom of the sea by the glacier. During the winter of 1860-1861 the previously insignificant glacier descended upon the low land and the grave-hillock on the shore, filled up the harbour, and extended far into the sea. It now constitutes one of the largest glaciers of Spitzbergen, from which immense blocks of ice constantly fall down, so that not even a boat can venture in safety beneath its broken border."

Desirous to ascertain whether the glacier had undergone any further alteration during the last ten years, I undertook, in the summer of 1873, a dangerous row through the northern entrance to Van Mijen Bay, along the border of the glacier to Coal Mount. The point of the glacier was thought to have advanced still farther, and it had now, if on a smaller scale, a complete resemblance to the glaciers which occasion the formation of the ice-fiords of Greenland, and which are sketched in *Redogörelse för en expedition till Grönland* (Narrative of an Expedition to Greenland) (Öfvers. af Vet.-Akad. Förh. 1870, s. 1009). See GEOL. MAG. 1872, Vol. IX. p. 362.

Recherche Bay in Bell Sound.—A comparison of the existing configuration of the land in this bay with the very accurate map which was constructed by the French Expedition in the Recherche in the year 1838, shows that the glaciers have considerably advanced. Unfortunately time did not permit us completely to map the fiord anew, on which account a complete comparison of the extent of the ice before and now was impossible. That the ice in this harbour has considerably advanced during the latest centuries is further proved by the remains of old train oil boiling places found in Robert's Valley, about two kilometres from the present shore, close by the side of a completely broken glacier, which here enters the sea, and which evidently has completely filled up the harbour where whalers anchored a couple of centuries back.

Whales' Bay in Stor Fiord.—According to the account of the whalers, the old harbour here has been of late years completely filled by a glacier.

Similar advancing glaciers probably occur in a great many other places along the coasts of Spitzbergen; for example, the inner part of the Stor Fiord, the bottom of Wahlenberg Bay, etc. It is, however, probable that the advance at these places corresponds to a receding at others, though it is difficult to give instances of this, on account of the non-existence of old detailed maps,[1] and that the changes which have manifested themselves during the later centuries in the extent of the glaciers have mainly depended on changes in the direction of the ice-streams by which the inland mer de glace debouches into the sea. Besides, the period of time during which direct observations have been made in these regions is too short to afford us any certain information as to the changes which the country has undergone in climatic and geographical respects. It is by studying its rock-formation and by examining the animal and vegetable remains which lie embedded in its various sedimentary strata that we first obtain an idea of the former state of these regions now so ice-covered.

In giving a description of the rocks, I shall follow the order of succession, and so begin with the oldest, viz.:

I. *Crystalline rocks.*—The crystalline rocks (granite, granite-gneiss, gneiss, crystalline limestone, mica-slate, hornblende-slate, etc.), which occur at the north-western corner of Spitzbergen, at Verlegen Hook, and the north-eastern shore of Wijde Bay, the north coast of Nordland, the Seven Islands, and the innermost part of Wahlenberg Bay, were found also in 1870 by Nathorst and Wilander in Klaas Billen Bay, in the innermost part of it on the north-east side, both on a mountain near the great glacier, and on the north side of the same mountain chain round a smaller glacier. At the latter place the ground-rock consists of mica-slate, gneiss, hornblende-slate, and quartzite, and is overlain *unconformably* by sandstone and clay-slate containing coal, followed by a stratum of red and white gypsum. Near the large glacier the formation is nearly the same, inasmuch as mica-slate with garnets and gneiss is overlain *unconformably* by sandstone and bituminous slate. In the sandstone were observed a large *Stigmaria* or *Sigillaria*, and an impression of a *Calamites*, which show that these strata belong to the Lower Carboniferous series ('Ursa' stage, Heer). The above-named places on Klaas Billen Bay are the only ones on Ice and Bell Sounds where crystalline rocks occur in position, but erratic blocks have been found in many places, and consist in some cases of a very coarse-grained porphyry-like granite, which we have not found *in situ*, though it is probable it is to be found under the mer de glace in the interior.

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[1] A comparison of the old Dutch maps with the present configuration of the country appears, however, to show that the mer de glace on the north side of Ice Sound formerly filled the whole of that arm of the Sound which is named North Sound, and that thus *the ice-covering at this place has considerably receded.* It is otherwise difficult to explain how Ice Sound, the next largest fiord on Spitzbergen, is delineated in these maps as very small, the north arm being completely left out, while the southern shore of the sound is drawn, if not correctly, at least recognizably. No similar discrepancy between the old maps and the present form of the fiords occurs in the case of *Bell Sound*, *Liefde Bay*, and *Wijde Bay*. In *Stor Fiord* (Wybe Jans Water) the ice, on the contrary, is thought to have advanced to the two islands in the bottom *of the fiord which in Van* Keulen's map are named Walrussen *and Robben Eyland, and which are believed to* be now surrounded by ice.

II. *Hecla Hook Strata.*[1]—We have not had the good fortune to find in Spitzbergen any strata containing Silurian fossils. But it is probable that the Silurian formation of Scandinavia is correlated to the immense succession of strata occurring here, which I, in the absence of any other name, have called after the mountain (Hecla Hook on Treurenberg Bay) where they have their greatest development. These strata, which besides occupy an immense area in Spitzbergen, consist, without taking into account inconsiderable variations, of

1. Lowermost, grey compact dolomite intersected by white veins of quartz and calcite. It was taken at first for grey limestone before it was analyzed by G. Lindström,[2] who found it to consist of grey dolomite from English Bay:

Carbonate of lime	53·98
Carbonate of magnesia	44·69
Carbonate of protoxide of iron	0·18
Incombustible residue insoluble in acids	1·39
Chlorine	trace
	100·24

2. Black clay-slate.
3. Hard whitish grey or red quartzite.
4. Black clay-slate, at certain places passing over to a breccia-like mixture of pieces of clay-slate and a hard sandstone containing lime.
5. Grey dolomite, like 1.

The Hecla Hook strata (quartzite and white-veined dolomite) occur in the part of Spitzbergen now referred to, in the rocks at the mouths of the fiords, along the outer coast between the fiords, and upon the islands and rocks by which the outer coast is environed; for example, *dolomite* with veins of limestone on the western side of Safe Haven, *quartzite* at the Alkhorn, upon the outer archipelago between Ice and Bell Sounds, and forming the rocks on the shores of the neighbouring coast in St. John's Bay, on the southern point of Charles Foreland, etc. To this probably also belongs the Clay-slate breccia, which immediately underlies the Tertiary strata at Cape Lyell.

The strata which belong to this group are most frequently raised up vertically, having their direction principally from north to south. It is exceedingly remarkable that we have not happened to find in them any fossils, though diligently examining series of strata thousands of feet in thickness, and although the Hecla Hook slate, on account of its fineness and the absence of pyrites, seems specially adapted to preserve the organisms which were imbedded in it.[3] Probably this series of strata are an extensive fresh-water formation from the same period of time as that during which the Silurian strata were deposited in Scandinavia.

III. *Liefde Bay Strata* (probably forming the boundary between the Carboniferous and the Devonian formations).—The above-mentioned quartzite is overlain in Lomme Bay by slate, limestone, sandstone and coarse-grained conglomerates, remarkable for the quantity of oxide of iron they contain, whence their red colour is derived, which, when the strata are broken down, communicates itself not only to the streams which run down the sides of the hills, but also to the water in the fiords which are surrounded by these strata.

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[1] Since the publication of my Sketch of the Geology of Spitzbergen, I have had the good fortune to find fossils in the red schists at Liefde Bay. These strata, which I formerly correlated with the Hecla Hook formation, I have now accordingly referred to a separate division, "the Liefde Bay Strata."

[2] G. Lindström, Analyses of Rocks from Spitzbergen, Öfversigt af Vet.-Akad. Förh. 1867, No. 10.

[3] Yet some indistinct and undetermined bivalves and inconsiderable graptolite-like impressions occur at the outer shore of Grey Hook in a black slate, which probably belongs to No. 4 of the Hecla Hook strata.

In Lomme Bay, the interior of Wijde Bay, Liefde Bay, Red Beach between Röde Bay and Liefde Bay, also in the interior of Ice Sound, these strata occur as a completely homogeneous formation in a geognostic respect, and nearly as poor in fossils as the strata in the before-mentioned group. Yet Malmgren and I in the Expedition of 1868, and Nathorst and Wilander in 1870, had the good fortune to find in them scales, dermal plates, and fin-rays of fishes, the shell of an ostracod crustacean, coprolites, etc., which, however, cannot yet with certainty be determined.

The shores of Dickson Bay are taken up (with the exception of several strata of gypsum and quartzite belonging to the next division, which occur nearest the entrance of the bay) completely by these strata, and they also occur strongly developed on the northern shore of Klaas Billen Bay, also in the bottom of Ekman Bay. On the other hand, they are generally wanting between the Hecla Hook strata and the Lower Carboniferous series on the west coast.

With reference to the occurrence of the Liefde Bay strata in Klaas Billen Bay, I have received a private communication from Dr. Nathorst to the following effect:—"Red and green clay-slate occur immediately to the north of Skansberg in the neighbourhood of the astronomically determined point. The slate has its dip first towards the west, which quickly increases till the strata are perpendicular, and then about 80° towards the north-east. Upon these strata rest layers of Russian Island dolomite and Mountain Limestone with nearly horizontal beds. In the neighbourhood of the astronomically determined point fish-scales and an ostracod crustacean occur plentifully in the slate. The red and green slates, which at first are covered by Mountain Limestone near the level of the sea, are elevated higher the further we advance into the fiord, till they finally form the mass of the mountain. Immediately south of Mimer's Bay the slates disappear all at once, and are replaced by a red sandstone with layers of gypsum, raised up in the same manner as the slates. A profile along the western side of Klaas Billen Bay would present somewhat the following appearance."

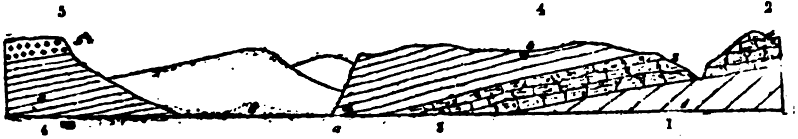

FIG. 2.—Profile of the Western Shore of Klaas Billen Bay on both sides of Skans Bay.

1. Liefde Bay strata, containing fish-scales, etc., in the neighbourhood of a cairn raised at the point the position of which was astronomically determined in 1864. 2. Russian Island dolomite, gradually passing into 3. *Cyathophyllum* Limestone or dolomite. 4. Layer of grey gypsum, at *a* full of white alabaster nodules and containing mountain limestone fossils, though sparingly. 5. Diabase. 6. Skans Bay.

This is probably a fresh-water formation deposited in a lake which stretched from the interior of Ice Sound over the south of Wijde Bay and Liefde Bay northwards.

IV. *The Carboniferous Formation.*—This period is represented in Spitzbergen by three divisions, namely: A. *The Lower Mountain Limestone.* B. *The Mountain Limestone proper.* C. *The Upper Coal Formation.*

A. *The Lower Mountain Limestone* ("Ursa-stage").—These strata occur most developed on Bear Island, whose geological phenomena were examined by me in 1868, and later were described in an appendix to the treatise (Fossile Flora der Bären Insel von Osw. Heer, Vet. Akad. Handl. V. 9, No. 5, 1871, s. 25) in which Heer describes the vegetable impressions found in these strata.[1]

From the researches which have since been made by Nathorst and Wilander in Ice Sound, it appears that the stratum named Russian Island dolomite, which, in the paper referred to, I considered to belong to the lowermost division of the Carboniferous formation of Spitzbergen, in fact lies between the Coal-bearing sandstone and the *Cyathophyllum* Limestone, and that thus the Coal-bearing sandstone forms the lowest link of the formation, provided the Liefde Bay strata placed in the foregoing division be not also referred to this one.

This division consists on Bear Island of:

1. (Lowermost) A hard, white, quartzite-like sandstone, with marks of the action of waves.
2. An irregular, darker sandstone layer with band of coal, 2·5—0·1 metre.
3. White, hard, and compact sandstone, without vegetable impressions, 3 metres.
4. Grey, pretty loose sandstone, 1·2 metre.
5. Sandstone with band of slate, about 0·5 metre.
6. Clay-slate with beautiful vegetable impressions and nodules of clay-ironstone, 1·2 metre.
7. Coal with band of clay-slate and numerous vegetable impressions, 3·5 metres.
8. Sandstone with stems of Calamites, of which a part stand upright and are of considerable size, 6 metres.

The same strata occur also in Ice and Bell Sounds, although, as far as is hitherto known, less developed than on Bear Island.

In Bell Sound several vegetable impressions, probably belonging to this formation, were already discovered by Robert, and delineated, though not recognizably, in the great work on the voyage of the Recherche;[2] according to the determination by Robert the vegetable impressions delineated are those of a *Lepidodendron* and a *Sigillaria* or *Calamites.* Robert, however, fell into the mistake of referring the whole of the overlying series of Tertiary strata to the Coal-formation. In the year 1873 I too had the good fortune to find on the north shore of Bell Sound, on an island situated a little outside Axel's Islands, a sandstone with numerous ill-preserved impressions of *Calamites* and *Knorria*; opportunity however was wanting for a stay sufficiently long for a close examination. It is, however, probable that the sandstone here underlies the *Cyathophyllum* Limestone, etc., upon the shore right opposite Axel's Islands, and the locality of the discovery deserves a closer examination. The profile of the strata at this place will be given further on.

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[1] See Dr. Oswald Heer's paper "On the Carboniferous Flora of Bear Island (lat· 74° 30′ N.)," Quart. Journ. Geol. Soc. Lond. 1872, vol. xxviii. pp. 161–173, pl. iv·

[2] Voyages en Scandinavie en Laponie au Spitzberg, etc. Atlas Géologique, 19· Paléontologie de la rade de Bellsound.

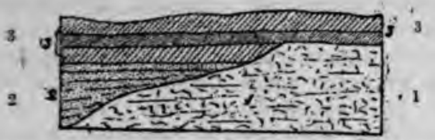

FIG. 3.—Section of Strata on the North-east side of Klaas Billen Bay, close to the great glacier (according to Dr. Nathorst).
1. Crystalline Slates. 2. Sandstone and Calcareous Clay-slate, with vegetable impressions. 3. Red and White Gypsum.

In Ice Sound, strata with vegetable impressions belonging to this division were found by Nathorst and Wilander in the summer of 1870:—*a.* right opposite Skansberg, on the east side of Klaas Billen Bay, where occur: 1. (lowermost) Sandstone and conglomerate of sharp-cornered pieces of quartz; 2. A sandstone-like clay-slate with thin coal-band, and impressions of *Lepidodendron*, *Stigmaria*, and *Calamites;* 3. Red Sandstone and a variable red, yellow, or green conglomerate of Liefde Bay, red and green slates, and 4. Russian Island dolomite with flint; 5. Strata containing beds of gypsum, flint, and a great number of marine fossils. Strata 1–3 dip steeply towards the Sound under the Mountain Limestone strata (4 and 5), which lie horizontally;—*b.* in the inner part of the Sound, in the neighbourhood of the Crystalline rocks, which here are directly overlain *unconformably* by red sandstone and clay-slate containing lime. The sandstone contained a large *Stigmaria*, and a portion of a *Calamites.*

(*To be continued in our next Number.*)

IV.—NORTHUMBERLAND ESCARPMENTS AND YORKSHIRE TERRACES.[1]

By HUGH MILLER, F.G.S., Assoc. Royal School of Mines;
Of H.M. Geological Survey of England and Wales.

IN framing a theory attributing the terraced form of limestone outcrops in the Yorkshire Dales to glacial erosion, Mr. Goodchild was doubtless prepared to encounter much adverse criticism. If in this communication I venture to differ from his views, he will believe that it is in no captious spirit. The district in Northumberland from which I write supplies materials for criticism of the most relevant kind, presenting as it does the same series of Carboniferous rocks cropping out in surface features closely allied, and subjected in the Glacial Period to the pressure of the same ice-sheet. The terraces of Wensleydale, too, are not wholly unfamiliar to me.

The elevated plateau occupying the angle between the two main divisions of the River Tyne, and traversed in a 12-mile walk between Haltwhistle on the south and Wark on the north, exhibits a series of escarpments, which, as illustrating the phenomena attending their development, is probably unsurpassed in the kingdom. The solid Mountain Limestone of the South of England—in Yorkshire divided up by intercalated bands of shale and grit, among which the limestones project in terraced outcrops—is here represented by beds seldom exceeding 30 feet in thickness, and, speaking generally, averaging scarcely 15. The sandstones, on the other hand, which take in Yorkshire the subordinate place, have become thickened and often massive, while the shales are similarly augmented. The outcrop of these beds of sandstone, limestone, and shale, forms a marked system of roughly parallel ridges and furrows crossing the watershed of the country from W.S.W. to E.N.E. The long-drawn hollows between projecting lines of outcrop are occupied mainly by shale, serving as an offset to the outstanding beds. The sandstones rise into the more prominent ridges, yet conform neither at base nor summit to horizontal lines, a consequence, in part, of their varying bedding and texture: here, where massive, advancing and rising along the line of a dip moderate in amount, until terminated in a precipitous front; there, withdrawing with bay-like recesses, whose inner sloping margin represents the subsided escarpment, or sinking temporarily until no feature marks their site. The limestone features are of subordinate character, generally rising into an angular wave, whose shortened front is roughened into an incipient crest, or entering into the profile of the talus-like skirt of a sandstone cliff as a somewhat subdued ledge or boss.

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[1] See Mr. Goodchild's Article, GEOL. MAG. July and August, 1875, pp. 323, 356.

Dominating the features of the district, the igneous Whinsill, simulating an interbedded appearance, and showing, like the other escarpments, dip-slope and scarp, runs like a great black *carina* among minor enflanking ribs.

This system of ridges with intermediate furrows, although differing in appearance from the terraces of the Yorkshire Dales, would, notwithstanding, assume a terraced character if ranged along the sides of a valley. This fact is sufficiently exemplified in the neighbourhood. In the wide valley through which the Houxty Burn joins the North Tyne, the sandstones, masked as they are by superficial deposits, and only partly favoured by dip, yet crop out occasionally in the form of wall-faced esplanades; one marked instance resembling in no remote degree the well-known Leyburn Shawl of Wensleydale. We have here also a gradation between the terraced and the ridged form; a gradation doubtless to be met with in many places intermediate between Yorkshire and Northumberland.

If the identity of the phenomena in the two counties be granted, as I think it must, the same causes must be looked to for their explanation. Two theories, rejected by Mr. Goodchild for the Yorkshire terraces, are still less applicable to the features here described. It is impossible that either rivers or the sea should carve out a parallel series of furrows coinciding with soft beds, and of ridges formed by harder ones. And when the series bears relation not to any water-level or levels, but to the grander features of the country, upon which it is chiselled as merely, so to speak, the minor orna-

ntation,—and when, moreover, it is found in the best preservation
the water-shed of the country,—marine and fluvial theories must
arly be set aside. Two theories remain. The first—supported,
d for certain districts established, by Ramsay, Greenwood, Foster,
d Topley, and others—attributes the etching out of these features
the protracted influence of atmospheric disintegration ; the other—
unciated by Mr. Goodchild—calls in for the Yorkshire terraces, and,
I trust I have shown, necessarily also for the Northumberland
carpments, the force of glaciers eroding unequally along beds of
equal resistance.

West Northumberland offers a fair field for testing the latter theory.
here the ice-sheet can be proved to have passed athwart the escarp-
ents, and full against their scarped faces, it could not have been the
use originating them. However, the striated and *moutonnéed* rock
rfaces, transport of boulders, etc., agree in recording that the ice
ved from the west in a direction sufficiently near the E.N.E. strike
the ridges to favour Mr. Goodchild's theory in a high degree. In
least later glacial times a certain obliquity of flow tended against
e scarped slopes, but as rock-markings tell of but the later and last
aciation, an allowance must be made and the coincidence assumed
complete. The harder lines of bedding must, therefore, have
ithstood erosion, and the softer yielded to it, and assuming a plane
rface to begin with, the result might somewhat have resembled the
resent featuring; though whether so much sharpness of outline
ould have been attained is more than questionable.

In proceeding further it will be necessary to summarize Mr. Good-
hild's evidence, (1) negativing the atmospheric disintegration theory
applicable to the terraced outcrops of the Yorkshire limestones,
nd (2) supporting his theory of their origin by glacial erosion. To
his will be added (3) a statement of collateral difficulties raised.

1. *Negativing the Atmospheric Theory.*—Except near the outburst of
prings there is but little disintegrated rock scattered about the
mestone outcrops. The dip-slopes, instead of showing excessive
igns of weathering on their front portions first uncovered and there-
ore longest exposed, seem equally weathered over the whole surface.
he swallow-holes also that pit the inner margin of the slope are
rcular cavities, not trenches lengthened in the direction of dip-
ope; they have therefore originated where they are. Glacial
ratches occur within a few feet of the present outcrop of shales
d limestones, thus putting a close limit to the amount of denuda-
on accomplished post-glacially. The extreme slowness of at-
ospheric disintegration is proved by a comparison of the gradual
cession of a waterfall with that of the steep sides of the gorge it
aves. In one extreme case the former receded 40 feet to the 1½ ft.
each side.

2. *Supporting the Glacial Theory.*—The development of the strata
sandstone, limestone, and shale, is not in the ratio of their durability
der atmospheric disintegration, but as their resistance to mechani-
lly grinding force. Under the former agent limestone ranks lowest,
ving to its comparatively great solubility in acidulated water;

under the latter it stands foremost, as it accordingly does in featural prominence.

3. *Collateral Difficulties.*—The regularity with which the terraces extend along the Dale sides and their correspondence on opposite slopes.—Their perfection at considerable heights up the sides.—The persistence with which they follow a disturbed bed "through all its variations of position and inclination."

Most of these points apply with equal force to the Northumberland district of Yoredale rocks which has come under my observation, thus affording an additional proof of the identity of the phenomena in the two districts. But in Northumberland they are attended by a sufficiency of convincing proofs that the escarpments —terraced or otherwise—are of pre-glacial origin, and by an explanation of most of the difficulties I have—correctly, as I trust—summarized. To state these in detail is the object of this communication, in which I am perforce more local and special than Mr. Goodchild found it necessary to be.

1. *Proofs of the Pre-Glacial Age of the Escarpments Afforded by their Relations to the Drainage.*—The general relations of the drainage system to the ranked lines of escarpments among which it ramifies strongly suggest their pre-glacial origin. Evidently no high barrier-ridges existed, to coerce the waterflow along single lines, or to pond it by sudden obstructions. There is, it is true, a tendency to prefer the intermediate hollows, as if the present configuration had been faintly marked out—though in a degree perhaps only appreciable to the unerring selection of water—when channels were first sought. But it is the larger gradient—that to which the summit lines of the escarpments themselves give the index—that determines the general direction of flow; and between the stream crossing the ridges at right angles and almost ignoring their presence, yet occasionally deflected along a furrow, and that occupying single grooves for long distances but now and then shunting, as it were, its line of flow, there is a graduating series of zig-zag courses, in which the *furrow* line tends more and more to subtract from the *gap* one. This *à priori* probability is well borne out. 1st. There is no evidence that the stream waters were dammed back by the escarpments now breached. 2nd. Streams are found to strike across escarpments at points where—closing the gap—their course was free elsewhere. 3rd. Occasionally a transverse gap contains a glacial deposit or gives other evidence of its pre-glacial origin.

A single stream affords most of these proofs, that, namely, which, after entering and threading a portion of the tract of typical escarpment development, passes by the village of Simondburn on its way to the North Tyne. The first good escarpment encountered by it is of sandstone, and above the average height. The sides of the gap slope at about 20°, and converge pretty directly upon the stream, like the limbs of a V towards a blunted apex. The height (about 50 feet) is sufficient to cause no mean lakelet, yet neither basin nor peat-moss (of which there are numbers in the neighbourhood) fronts the gap, nor do the stream sides expose lacustrine deposits: 10 or feet above it glacial drift is indicated. A few yards further east the escarpment, though gapped at its maximum height, has sunk completely down, the feature being merged in a peat-moss, the surface of which, padded out by vegetable accumulation as it is, is yet considerably below the summit of the gap. The stream had thus only to flow on a little further to obtain a course unimpeded. It is necessary to add that this gap, unlike the great majority, is traversed by a fault of some 15 feet throw; but agreement will probably subsist between glacialists and sub-aerialists that a closed or nearly closed fault, crossed at right angles by a glacier, could offer no vantage for the excision of a narrow notch. That the point of weakness should have been chosen when the escarpment was in its infancy explains everything.

Passing down with the stream, we find it borne along the base of the next escarpment for fully a mile contrary to its destination, when it doubles through another gap. This it is necessary to describe somewhat more accurately. The feature crossed is of a compound character, and no fault exists. From the middle point of a line drawn across the forefront of the gap to the end of the dip-slope at the further side is a distance of 280 yards, and rather more than 100 yards within the former an exposed face of 'till' of the usual type (with scratched stones partly local, partly of western origin) slopes up from the water's edge. About 25 yards further in, rock is seen on both sides, and the breadth of the gap determined thereby at 50—60 yards from brow to brow, the slope of the banks varying from 30° to 23°. That this is a pre-glacial gap in an escarpment demonstrated as also pre-glacial is a fact which admits of no doubt. Glacial markings—nearly coinciding with the trend of this and other escarpments—occur just half a mile distant, and nothing intervenes to modify the line of motion there indicated. Neither—I must add—does the gap present coomb-like features; it is a simple notch rasped out by pre-glacial stream-action, in the shelter of which—while glaciers swept over and by it—debris lodged.

Passing on yet again, we are carried half a mile nearly parallel but contrary to the westward deflection terminated as just described, and then find the stream deviating to slide through a third gap. This presents mainly the features which the other two have in common. The point chosen, however, is that of a local deterioration in the bedding of a sandstone which advances and rises on either hand into crags. The gap thus terminates a wide angle, into which the dip-slope of the inferior bed thrusts itself like the point of a broad knife towards its sheath. Of this I will only say: 1st, a glacier would have left not an angle but a curve; 2nd, the stream was not compelled to cross here; and 3rd, there is nothing to show that its course was ever obstructed previous to forcing a passage.[1]

The course of the Crook Burn—aptly so named—is nearly along one line of strike for the next two miles, but we need follow it no farther.

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[1] Exceptional cases occur in which such ponding did take place. In these the waterflow found itself barred by accumulations or intercepted by basins, neither of which existed before the Glacial Period.

Before quitting this portion of the subject, I may adduce one other proof of the pre-glacial origin of gaps—derived from the Whinsill. This basaltic dyke is interrupted by numerous narrow steep-sided breaks not usually stream-traversed. The edges of these—especially, I think, those opposing the glacier—bear the characteristic *roches moutonnéed* aspect; while the interiors, lying out of the reach of a planing agent, are untouched. The bearing of this fact upon the present question cannot be mistaken.

2. *Relations of the Escarpments to Glacial Erosion.*—The escarpments, as already stated, are by no means of equal development along their line of strike. Sometimes, when favoured by the constitution of the rock, they stand boldly out; but anon the bedding or texture alters, and they lower and subside—often being temporarily lost altogether. Even the best-marked escarpment is thus separated up into segmented portions, which, in general, present in front view an arched outline—a rounded middle development sloping or curving down east and west. Bearing in mind that the glacier passed eastward nearly along the axis of each escarpment, it will be remarked that we have here the conditions most favourable to the formation of *moutonnéed* outlines;—of a long, smooth, sorely abraded side facing the glacier, and a steeper sheltered one averted from it. It is a fact, nevertheless, of strikingly constant recurrence, that the segments described turn their steeper slopes westward, the acclivities opposed to the glacier often being so abrupt as to remind one of sloped gables. This fact, apparently unconnected with any peculiarity of internal rock-structure, I believe to be explicable by the prevailing westerly winds causing excessive weathering and more rapid recession on that side; for, as the *dorsum* of each segment is the most massive and durable portion of the bed, the frequent beat of the rain swept eastwards must eat further in towards the solid core of rock, the slope thus weathered partaking more of the abruptness of the escarpment's middle face. How exposed that western side is to the battering of the elements, many old buildings amply testify. The eastern side may be comparatively smooth and even, each block rectangular, and some tool-marked, and the mortar nearly continuous between surfaces; while the western side is deeply weather-scarred—the stones projecting in rounded bosses, and bounded by crevices, whence mortar has been removed. The material disintegrated from the stones of the westward face of the old peel-tower of Chipchase Castle (date about 1280) must amount to several ounces apiece, while decay has scarcely touched the sheltered sides. To the same cause the feature above described may probably be imputed, but in any case it gives no countenance to the theory of the glacial origin of escarpments.

Assuming, however, that such was their origin, that each escarpment was progressively developed by the removal by ice of a softer bed covering it, the portion of the dip-slope latest bared would necessarily be saved vast erosion, of which the brow bore the full brunt. The profiles of the longer dip-slopes—in the case of the Whinsill sometimes exceeding 700 yards—would therefore be found to thin towards their scarped face like the blade of a carpenter's chisel towards its edge, except probably more curved in outline. When quarried or cut into along the line of slope, the dip of the beds might even be seen to exceed the angle of the declivity. But though opportunity and observation have not been wanting, I have never found this to be the case. The front of a sandstone escarpment sometimes attests the tendency in being, not squared, but rounded off, like one side of a *roche moutonnée*. The extent to which this occurs, however, scarcely bears out the views of extreme glacialists, though something must be allowed for the subsequent weathering of the escarpment.

Having, as I think, given good reasons for dating the escarpment system of West Northumberland back to a period anterior to the Glacial epoch, I will pass to a consideration of the proofs and objections advanced by Mr. Goodchild.

In stating the order of resistance of the Yorkshire Yoredale rocks to mechanical erosion, as 1 Limestone, 2 Sandstone, 3 Shale, Mr. Goodchild's grounds are probably indisputable. But it seems to me quite otherwise with his conclusions regarding their durability under atmospheric disintegration. In the cliffy faces bared at the angles of a winding stream, strata of sandstone, limestone, and shale are sometimes exposed in such a manner as to exhibit their respective relations to weathering. The face of the beds of shale is invariably concave, while sandstones and limestones of equal thickness project about equally.[1] Their durability is usually directly in proportion to their thickness. A limestone compared with a sandstone double as thick is found to have shrunk further back, but is in advance of sandstones thinner than itself. So far as this evidence can be relied on, it distinctly negatives Mr. Goodchild's proposition that sandstone is notably the most durable, that second to it comes shale, while limestone, subject at once to disintegration and dissolution, is more destructible than either.

The two kinds of reducing atmospheric agents, classed as mechanical and chemical, can scarcely be assumed as mutually complementary in their working, especially in regard to blocky limestones such as those of Wensleydale. Chemical action corrodes the outsides of the cuboidal masses, and by widening the joints retards the great agent of mechanical disintegration—frost—in its work of sundering *en bloc*. For, from the non-granular texture of these limestones, frost, as detaching particle by particle, can gain little hold, and hence the chief planes open to it are those of jointage and stratification, which together determine the rock into squared masses. A stage may be reached at which frost is impotent to achieve much, and the limestone, built up of loose blocks, may be compared, not inaptly, to a "dry stone dyke," said to be the most lasting kind of wall for upland districts, and can then be attacked chiefly by the dissolving action of soft water—action distributed along the lines of jointing to great depths below the outcrop. The sandstones, on the other hand, are exposed to frost not only along their (more irregular) joints, but grain by grain; while the calcareous and felspathic elements are liable to be reduced and abstracted by chemical action, with the effect of loosening the texture, rendering it porous, and thus giving frost a better grip.

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[1] In many cases the two harder beds are so rapidly undermined, owing to the hollowing out of the shale, as to have little chance of becoming weathered to any great extent.

For these reasons it is open to doubt whether, bed for bed, the Yoredale limestones are much more rapidly removed than the sandstones. But the chances of a bed making a good escarpment are directly in proportion to its thickness, which in Yorkshire favours the limestones, in the Tynedale area the sandstones. In this I believe lies the explanation. Just as in the stream section, where sandstone and limestone projected or retired, according to their several thicknesses, so I believe it to be in regions where these rocks crop out in a manner favouring escarpment development. And as the system for limestones with grits in the south, and sandstones with limestones in the north, is a dovetailing one, there is probably some intermediate tract of equal development where both are favoured alike.[1]

In nearly all cases shale is inferior in durability to the other two, and where interlined even with thin courses of sandstone or limestone, shows a retreating outline, whether under escarpments or in stream-cut sections; and this not only where reached by spray, but in every shaly slope not smothered in debris. In certain cases, however, it is apparently durable, as, for instance, where it is backed up by harder rock, and permitted to assume slopes or to sink into hollows favouring preservation and encouraging a conservative covering of vegetable growth. In these cases the denudation of the framework of harder beds by atmospheric action may be said to measure that of the shale.

The difficulties and objections raised by Mr. Goodchild to the disintegration theory can perhaps best be treated of under two heads. 1. Those affecting the character and rate of disintegration of rocks. 2. Those drawn from the local development of the outcrops.

1. With the view of proving the incompetency of atmospheric disintegration to cause great results, Mr. Goodchild gives measurements of blind gorges terminating in waterfalls in which the recession of the fall is contrasted with that of the sides of the gorge. It seems but a fallible test, however, to compare the wearing back of the latter through the crumbling waste of rain and frost with that of a waterfall employing all the tools of subaërial denudation. In comparing gorge with gorge, moreover, the mean annual volume of water would require in all cases to be ascertained; while the nature of the rock, varying even in the same material, and apt to be infinitely complicated by combinations of several kinds of rock, would present a formidable obstacle to the attainment of trustworthy results.

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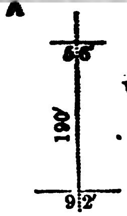
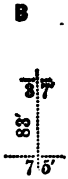
[1] That this is the case is, I think, indicated in Phillips's Geology of Yorkshire, *Section Physical Geography.*

I believe it to be possible, however, by selecting only such gorges as are post-glacial, to arrive at results of some value: 1st, as showing the actual amount of the scarp removed since the Ice Period; and 2nd, as a means of comparison between sandstone and limestone under weathering. I give the following measurements more to illustrate my meaning than as conclusive on the subject, which no single instance can be. The cases are taken from the neighbourhood of the village of Birtley, North Tynedale. A is a post-glacial gorge in sandstone and shale, occupied by a stream vigorous at least in winter, and doubtless rapidly lengthening. B is a short limestone gorge terminating in a rocky ledge now dry, but in the "Rain Period" succeeding the Glacial Epoch, and even during the extension of the forests swept away since the Roman Era, doubtless containing its waterfall. This evidence, so far as it goes, shows, 1st, that since the Glacial Period the waterfall of A has cut back 190 feet, while from each side 18 feet has been disintegrated; and indicates, 2nd, that the recession of a limestone scar from atmospheric disintegration has been to that of a scar of sandstone and shale as 19 is to 18.



Vertical Section.
Sandstone 8'-10'
Shale 20'



Vertical Section.
Limestone 18'-20'

Though I adduce these instances as in some degree bearing out my views, I regret that North Tynedale does not afford the materials for satisfactorily working out the question, which must be decided in a district supplying several instances of both kinds. Mr. Goodchild's method may then—with the amendations above proposed—lead to definite and interesting conclusions.

One fact is sufficiently clear, namely, that atmospheric disintegration is an agent so gradual that little can have been accomplished by it in post-glacial times. Accordingly it is only to be expected that the quantity of debris strewn about the escarpments should never be very great. In this respect there is indeed, a marked difference between the sandstone and the limestone outcrops of West Northumberland. The former are sometimes considerably ruined; the latter are, on the contrary, so free from dislodged fragments that it is rare to find many together. This fact explains the paucity of debris remarked by Mr. Goodchild for the Yorkshire terraces. The isolated pieces toppled from the limestone scars are even more exposed to reducing action than while *in situ*, while the opposite is probably the case with sandstone debris. It is to be remarked, too, that sandstone escarpments, even when standing over a pile of fallen blocks, give no signs of becoming buried in their own ruin. On the contrary, the more rapid the dislodgment and the larger the masses, the more clearly do the mural planes stand forth. With regard to the absence of severe weathering in front, alleged by Mr. Goodchild, it is certainly wonderfully inconspicuous; but I have shown that to accept the glacial hypothesis is by no means to get rid of the difficulty. Glacial erosion may well have been sufficient at least to remove any raggedness of surface or edge that may have been, leaving smoothly dressed surfaces for weathering to commence afresh upon.

When the strata are free from superficial deposits, the swallow-holes observable in the Northumberland limestones resemble those of Yorkshire, as described by Mr. Goodchild, in usually bordering the foot of the dip-slope. They are circular pits of the shape of a common filter, and although in most cases the circle is indented on one side by the feeding runnel, they exhibit no great tendency to lengthen out into trenches, even when copiously fed with peaty water. The amount of limestone removed from the external orifice is usually very trifling, seldom exceeding a foot or two in diameter. Indeed, judging from the dissolution effected in these cases by water acting under very favourable conditions,—namely, well charged with carbonic acid and constantly renewed,—it might well be thought that the liability of exposed limestone surfaces to dissolve has been over-estimated. From the frequency with which new swallow-holes are formed, I believe, however, that they either are temporary and liable to be discarded and filled up, or that they are of very recent origin. There is certainly no proof that any of them are pre-glacial, and from their inconsiderable depth, seldom over ten feet, they could not be expected to have weathered the Ice Period. It is impossible to affirm, then, that in pre-glacial times they did not witness more strongly to atmospheric denudation than they now do; the vertical fissures exposed in limestone quarries may well have given rise to swallow-holes atop, which travelled back, in the manner required by Mr. Goodchild, as the covering of shale was cut into.

The relation of springs to the escarpments, although interesting, I will not enter into. I am not aware that they are regarded as other than interferences with the regularity and sharpness of scarped outlines, still less as productive of symmetry such as frequently meets the eye in Wensleydale. In Northumberland coomb-like features are produced occasionally around their outburst, though of course in miniature.

Passing now to the features of local development of the Yorkshire terraced escarpments cited as difficult of explanation, two of these are probably stated as adverse only to the fluvial theory of the terrace-formation, and may be dismissed with a word. That scars should be in correspondence on opposite sides of a dale is due of course to the regular extension of the beds across the intervening space now excavated. Where the duplicate faces happen to crop out, there will the terrace rise into relief. The same reason applies to the persistence of the scars in accompanying disturbed beds "through all their variations of position and inclination." On the Glacial Erosion *hypothesis,* such sloped outcrops would be related to a glacier moving along the strike either as the *stoss* or the lee side of a *roche moutonnée*, and become moulded accordingly. This, so far as I know, is not the case.

The greater perfection of the Dale terraces at high altitudes is strictly paralleled, I think, by the bolder character of the escarpments on the watershed of Northumberland betwixt the Tynes, and is susceptible of the same explanation. The influences of rain and frost, shed broadcast over the face of the country, are at higher levels less interfered with by the concentrated and rapid agents of denudation, and are thus permitted to prick out a configuration purely determined by the relative resistance of the materials acted upon. In the Yorkshire Dales, too, the lower-lying scars have probably been smoothed back by the ice with which they brimmed during the Glacial Period. The valleys necessarily added their own depth to the thickness of the ice-sheet, and taking the case of one 500 feet deep, the erosive force acting on the bottom would be 243,000 lbs. per square yard[1] greater than the pressure on the summit of the valley wall. In the beautiful basin containing Loch Semerwater (near Bainbridge, Wensleydale), I had remarked the obscurity of the terraces on the lower slopes. The glacier force concentrated in the excavation of the loch must have extended some distance up the sides planing the outcrops back, but high on the west side they stand out with great individuality and in form almost rectilinear.

Having thus, as I think, met Mr. Goodchild's arguments, I will in concluding epitomize the opinion for which, as for much else, I was first indebted to the vigorous teachings of the honoured author of the "Physical Geology and Geography of Great Britain." The question is not, How quick will an escarpment recede when once formed? but, Given a series of regularly outcropping sandstones, limestones, and shales in marked beds, what form will their outcrop in time assume? And I think there can be no doubt of the form they *must* assume.

NOTICES OF MEMOIRS.

"Ueber die Fauna der Gaskohle des Pilsner und Rakonitzer Beckens." Dr. Anton Frič. Sitzung der Mathematisch-naturwissenschaftlichen Classe der k. böhm. Gesellschaft der Wissenschaften am 19 März, 1875.

In April, 1870, Dr. Fritsch gave a notice to the Royal Bohemian Academy of the occurrence of animal remains in the Gas-coal of Nyřan near Pilsen, from which deposits he enumerated ten species of Saurian remains, Fishes, and Arthropoda. Since then the author has collected new materials, and has studied the specimens more in detail. Still more recently he has obtained a rich series of remains from the Gas-coal of Kounová, near Rakonitz, which exhibits a fauna identical with that of Nyřan. Of these localities he now briefly enumerates the series of remains. He considers his researches, however, as still incomplete, but he publishes the preliminary results, on account of the great interest which attaches, at the present moment to the question of the probable age of these deposits.

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[1] Tyndall, Phil. Mag. 1864, part ii. p. 285.

Vegetable remains from the Coal-shales are somewhat rare. But large *Carpolithes* and pyritized stems of *Psaronius* have been obtained, which require a more detailed examination before they can be described.

From the subjoined synopsis it appears that the locality of Nyřan furnishes twenty species, that of Kounová thirty species of animal remains; only five species are common to both localities.

In the Permian of Bohemia only four of these occur (see the table).

In comparing the Coal-measures of Bohemia with those of Saarbruch, Rhenish Prussia, only a few of the species appear to be common to both, namely *Acanthodes*, *Palæoniscus*, and *Gampsonychus*; whilst *Amblypterus* is absent, and the *Archægosaurus* of Lebach, Rhenish Prussia, is represented in Bohemia by a distinct type. Dr. Fritsch, however, does not consider his researches sufficiently complete at present to decide the relative age of these deposits.

TABULAR VIEW OF THE ANIMAL REMAINS HITHERTO DISCOVERED IN THE COAL-SHALES OF NYŘAN AND KOUNOVÁ, BOHEMIA.

	Nyran.	Kounová.	Permian formation of Bohemia (L. Dyas).	
1. *Melosaurus bohemicus*, Fr.	x	?		
2. *Labyrinthodon Schwarzenbergii*, Fr.	x	x		
3. *Microbrachis Pelicani*, Fr.	x			
4. *Scincosaurus crassus*, Fr.	x			
5. *Stelliosaurus longicostatus*, Fr.	x			
6. *Branchiosaurus salamandroides*, Fr.	x			
7. *Dolichosoma longissima*, Fr.	x			
8. *Sparodus validus*, Fr.	x			
9. *Urocordylus scalaris*, Fr.	x			
10. *Microdon modestus*, Fr.	x			
11. *Ctenocosta lata*, Fr.	x	x		
12. *Batrachocephalus crassidens*, Fr.		x		
13. *Ceratodus Barrandei*, Fr.		x		
14. *Palæoniscus sculptus*, Fr.	x		x	x
15. *Palæoniscus deletus*, Fr.		x		
16. N. G. *Kounoviense*, Fr.		x		
17. *Gyrolepis speciosus*, Fr.		x		
18. *Phyllolepis fragilis*, Fr.	x	x		
19. *Orthacanthus bohemicus*, Fr.	x	x		
20. *Xenacanthus Decheni* ?	x	x	x	x
21. *Xenacanthus levidens*, Fr.		x		
22. *Acanthodes pygmæus*, Fr.	x		x	x
23. *Acanthodes* sp.		x		
24. *Julus constans*, Fr.	x			
25. *Julus costulatus*	x			
26. *Julus pictus*		x		
27. *Estheria tenella*	x		x	
28. *Gampsonychus Krejschii*	x			
	20	13	4	3

REVIEWS.

-Petrographische Studien an den Basaltgesteinen Böhmens. pp. 294, with 8 coloured lithographic plates.

trographische Studien an den Phonolithgesteinen Böhmens. pp. 95, with 2 coloured lithographic plates. By Professor Dr. Emanuel Bořický. (Archiv für der naturwissenschaftliche Landesdurch-forschung von Böhmen, vols. ii. and iii. 1873–4.)

HE journal in which these valuable monographs are published is perhaps not so widely known among English cultivators of the tural sciences as it well deserves to be. Published in both the ech and German languages, under the direction of committees of dent and enthusiastic naturalists, having their head-quarters in rague, it contains the record of numerous original investigations on e topography, geology, palæontology, botany, and zoology of hemia; and we cannot but congratulate the cultivators of the tural history sciences in that country on the important contribu-ons which they are making towards the progress of science, and eir success in illustrating the natural features of their own very teresting country, to which the contents of these volumes bear such mple testimony.

The striking characters presented by the phonolites of the olcanic district of Northern Bohemia have long been made familiar o geologists by the descriptive writings of Reuss, Jokely, Jensch, nd Hochstetter, and the analyses of Rammelsberg and other hemists; but it was reserved for Dr. Boritsky to show that the asalts of the same district, when carefully studied, are of at least qual interest, and surpass indeed the similar rocks of any other rea in the remarkable diversity of characters which they present. t is certainly a noteworthy circumstance—to which our author draws ttention—that the whole of the varieties of basalt described in the lassical work of Zirkel on the "Basaltgesteine" are to be found in Bohemia, while he has been able to detect some new and interesting forms of the rock which are quite new to petrologists.

As exhaustive illustrations of the rocks of a particular district, these monographs of Dr. Boritsky are invaluable. During his investigation of the basalts he has examined more than 1000 sections derived from 400 different localities; and his conclusions concerning the phonolites are based on the study of 300 sections of rocks derived from 120 localities. But a very inadequate idea of these important works would be conveyed by merely noticing the microscopical studies which they record. Dr. Boritsky, who is an accomplished mineralogist and chemist, has in every case combined his microscopical with chemical and crystallographic researches, and, more than all this, has sought to follow up the results of his researches on the rocks in the laboratory by investigating their relations to one another in the field.

The monograph on the Bohemian basalts commences with a discussion of the optical and chemical characters presented by the different mineral species which are found in these rocks, and of the means by which they may be best identified under the microscope. No less than twenty-seven species or distinct varieties of minerals have been detected in these basalts,—namely augite, diopside, hornblende, diallage, bronzite, enstatite, hypersthene, biotite, rubellane, oligoclase, andesine, anorthite, labradorite (?), nepheline, leucite, haüyn, nosean, garnet, melilite, olivine, apatite, magnetite, hæmatite, titanite, picotite, pyrrhotine, and tachylite. Where, as in not a few instances, microscopic examination alone is inadequate for the determination of a constituent of the rock, the fact is candidly admitted by the author, and chemical or other methods resorted to.

As the result of these studies, it appears that the Bohemian basalts may be divided into six classes, which Dr. Boritsky defines as follows:—

I. *Magma-basalts*, consisting of a glassy basis, through which crystals of augite, olivine, and magnetite are scattered. The felspathic ingredient of the rocks has not crystallized at all, but remains in the condition of a glass exhibiting numerous microliths. This group of basalts is further subdivided by the author into a number of subordinate varieties, based on the colour of the glassy basis and the size of the crystals of the embedded minerals.

II. *Nepheline-basalts.*—In these the magma, in which crystals of the same minerals as in the last group are embedded, shows indications of breaking up into the crystalline forms of nepheline (*nephelinitoid basalt*), or finally passes into a distinct aggregate of nepheline crystals (*nephelinite*). This rock, like the last, exhibits many varieties of texture, and may also contain greater or less proportions of nosean or haüyn; and on these grounds it has been divided into a number of subordinate varieties.

III. *Leucite-Basalts.*—This rock shows, in a manner similar to the last, the gradual passage of a glassy magma into leucite and nepheline, and is divided, according to the more or less complete crystallization of its basis, into *leucitoid basalt*, *peperino-basalt* and *leucitophyre*; while other varieties are based on the size of the included crystals.

IV. *Felspar-basalts.*—These fall into three series:

1. *Melaphyre-basalt*, in which the basis remains to a great extent in a glassy condition.

2. *Common felspar-basalt*, in which the felspathic ingredient is distinctly crystallized out; but this proves, according to Dr. Boritsky, to be oligoclase or anorthite, and seldom or never labradorite!

3. *Andesite and Phonolite-basalts*, in which the basis consists of oligoclase felspar, with nepheline, leucite, nosean, etc.

V. *Trachy-basalt.*—In this group of basalts olivine never occurs, but the mass is made up of crystals of orthoclase and oligoclase felspar, and of nepheline and nosean or haüyn, among which are scattered others of biotite and hornblende, and more rarely of augite. The proportion of silica in these remarkable rocks only reaches *an average* of 45 per cent. It will be seen from the above descriptions that Dr. Boritsky's researches, though conducted quite independently of those of vom Rath in the Southern Tyrol; and of Szabo in Hungary, seem to lead to precisely the same conclusion as theirs,—namely, that but little importance can be attached to the supposed necessary association of the several felspars with different classes of rocks.

VI. *Tachylite-basalt.*—When the basis of a trachy-basalt assumes a glassy texture, the variety to which Dr. Boritsky applies the above name is constituted. It forms, however, only veins of a few inches in width, or the sides of dykes of larger size composed of trachy-basalt.

It might be anticipated from the peculiar mineralogical constitution of these Bohemian basalts that they would, in their chemical composition, present some differences from that of the normal rocks of the same class; and that such is really the case is proved by the numerous analyses, made by himself and other chemists, which Dr. Boritsky discusses in the third part of his monograph.

In the magma-, nepheline-, and leucite-basalts the per-centage of silica is exceedingly low, varying between 34 and 43 per cent. only; while the proportion of alkalies is high,—namely, from 5 to 10 per cent. Our space will not permit us to enter upon the consideration of the actual quantitative determination of the mineralogical constitution of the various rocks,—for which, however, the author supplies approximate estimates, based on a discussion of their oxygen ratios, etc.

In the succeeding part of his monograph, Dr. Boritsky proceeds to show that the several varieties of basalt were erupted during different stages of the great series of volcanic outbursts in Northern Bohemia, which, commencing with the Oligocene period, continued almost down to recent times.

The magma-, nepheline-, and leucite-basalts belong to the earliest period, and form the great lava-streams and tuffs which constitute the plateaux occupying so large an extent of country. These were succeeded by the different varieties of felspar-basalts, veins and intrusive masses of which are found penetrating them in all directions. Then came the period of the sporadic phonolitic outbursts, which Dr. Boritsky justly recognizes as rocks extruded in a viscous or semi-solid condition. And lastly the trachy- and tachylite-basalts—veins of which traverse the phonolites and other older masses—made their appearance.

The author is further of opinion that a relation can be detected as existing between the *prevalent directions* of the dykes of basalt and their petrological character and age. Perhaps, however, further evidence than is adduced in this memoir may be required, before geologists will regard this conclusion as fully established.

Of the concluding portions of the monograph, we can do no more than mention the subjects which they treat,—only premising that these are handled with the same thoroughness and ability which characterize the earlier parts of the works. In the first place, we have an examination of the interesting effects of local metamorphism, produced on the Cretaceous and other rocks, by the intrusion of the different varieties of basaltic rock among them; and of the nature of the minerals produced under such circumstances. And this is followed by a discussion of the nature of the secondary minerals formed in the cavities of the different basalts during their decomposition, and of the relations which these bear to the several original constituents of the rocks.

In his monograph on the Bohemian phonolites, the author follows the same general plan as in that on the basalts; we cannot, however, do more than notice its more salient conclusions.

The microscopical and chemical characters of the fifteen species of minerals found in the phonolites are in the first place discussed. These minerals are as follows: sanidine, triclinic-felspar, leucite, nepheline, nosean, haüyn, tridymite, hornblende, augite, magnetite, titanite, pyrite, spinell, mica, and apatite.

The variations in the relative proportions of the two principal constituents in these phonolites give rise to a regular series of rocks, ranging from the *nepheline-phonolites*, with from 45 to 37½ per cent. of nepheline and 43 to 50 of sanidine, to the *sanidine-phonolites*, with from 9 to 17 per cent. of the former mineral, and 58 to 71 per cent. of the latter. Between these extremes range numerous varieties, distinguished by the presence, in greater or less abundance, of leucite, nosean, haüyn, and oligoclase. Of such principal varieties Dr. Boritsky recognizes no less than eight, and he shows that an approximation to their mineral constitution may be arrived at from an examination of their specific gravities, their behaviour with acids, and their sulphur reactions. As in the case of the basalts, the nature of the metamorphic changes produced in the rocks through which the phonolites are extruded is very fully discussed, and also the nature of the minerals formed in their cavities during decomposition.

The limits of this magazine notice will not admit of our entering into any further details on the subjects treated in these valuable monographs; but we may add that the coloured lithographic plates which accompany them rank with the very best illustrations of the microscopic structure of rocks that have yet been published.

We need scarcely add any remark of our own upon the importance to the geologist of such detailed works on local petrology as that we have been noticing. When we possess a number of such contributions to the history of different volcanic districts, many important problems—such as those of the relative characters of volcanic materials in different geological periods, and in different areas during the same period—will obtain a satisfactory solution; while questions now relegated to the domain of speculation—such as that of the origin of volcanic outbursts from a central incandescent nucleus or from a number of more or less independent sources—will be brought within the sphere of inductive research.

We understand that Dr. Boritsky purposes to follow up these monographs on the Tertiary volcanic rocks, by a series of other memoirs on the petrology of Bohemia; and we are assured that alike in England, Germany, and France, where the microscopical study of rocks is now being pursued by so many earnest investigators, the appearance of these will be looked forward to with the greatest interest.

J. W. J.

II.—THE RECENT ORIGIN OF MAN, AS ILLUSTRATED BY GEOLOGY AND THE MODERN SCIENCE OF PRE-HISTORIC ARCHÆOLOGY. By JAMES C. SOUTHALL. (Philadelphia: Lippincott & Co.; London: Trübner & Co.)

WHILST the first rank must be accorded to original observers who add to the world's stock of knowledge, the second place must be assigned to those useful workers who weigh and place the stores brought in by the former. The latter merit belongs to Mr. Southall. He does not appear to be a votary of science, but an indefatigable and able collector of statistics. He avows himself, however, to be an advocate, and whilst he is comprehensive and fair in his collection of instances, he is acute in turning them to account in accordance with his theory, which is that of the recent origin of man on the earth.

The author affirms that history, commencing about 5000 years ago, opens with full-fledged civilization. That in the East there was no stone age, stone implements there being no older than metal ones; that the people of the stone age in Western Europe are offshoots from the East, and contemporaneous with its civilization.

The ninth chapter brings us to the critical portion of this portly volume. He discusses the megalithic evidence in harmony with the arguments of Mr. Fergusson, and sets down all the great stone monuments as recent, too recent to have any bearing on the question in hand. The eleventh chapter deals with the lake-dwellings, and claims them for all ages, and on the strength of some admixture of metal and pottery he urges that they are contemporaneous with civilization and the use of metal in other quarters at the same time.

The twelfth chapter argues that the Scandinavian refuse-heaps are not older than the lake-dwellings. Rude implements found in them prove only that they are the relics of rude fishermen and peasants. Iron and bronze not being known around the Baltic until after the Christian era, the absence of these metals proves scarcely anything.

The thirteenth and fourteenth chapters exhaust the caves. They are, like the preceding "finds," described in great detail and with fairness. Attempt is made to show a gradation backwards in occupation from modern days to the earliest without interval. From the instances in which the remains of the Mammoth epoch are mixed with those of reindeer, in the South of France, the contemporaneity of these animals with the former is argued. The Belgian evidence is also adduced in support of this. It is inferred that the men first inhabiting the caves were not only hunters, but manufacturers, potters, traders, possessing sundry furnishings of civilization.

"The sum of the matter is, that we find in the ancient cave-dwellers a race of men in almost precisely the condition of the modern Esquimaux; and there is a considerable probability that the Arctic races of Europe and America are their descendants.

"It was the first race that reached Western Europe from Western Asia, and the Celts subsequently pushed them further North."

Then we come to the discussion of Solutré,—an important, perhaps a crucial case. Here bones of the elephant are found together with those of 40,000 horses, associated with stone implements of all ages and fashions. Here we have the man of both periods in full life and in death. The similar admixture in a cave at Gourdan also points to a gradual transition from the very first traces of Somme-valley life conditions down to the historic era.

Next we arrive at the river-valley gravels, confessedly the most difficult portion of the inquiry. Mr. Southall first disposes of the peat in 2000 years, by the aid of canoes, bricks, and Roman remains. Then he is faced by the sub-lying beds of sand and rolled pebbles containing the mammalian remains with the rough flint implements. He adduces Mr. Alfred Tylor's calculations as to the forces of his pluvial period; quotes Belgrand to testify that the Palæolithic period passed rapidly away, and was succeeded by peat; and so brings down the dawn of the gravels to a few thousand years antecedent to the latter. The weak part of this argument is that it does not account for the great changes of level that we are told have occurred since or during the deposit of the gravels and the burying of the implements. Nor does it explain the fractures, displacements and replacements of the post-human period. The glacial rushes allowed by Sir Charles Lyell, the pluvial torrents of Mr. Tylor, the ocean incursions hinted at by Mr. Southall, will not account for all the phenomena,—even allowing Mr. Prestwich's opinion as to the formation of the valleys out of the chalk by large streams during the early human period,—in any time consistent with the Usherian chronology, unless we evoke the aid of great crust disturbances since the visits of Palæolithic man and before the advent of his historical successor. If such a period of comparative cataclysm can be established, on the evidence of the Straits of Dover and analogous appearances, then the advocates of the short chronology may boldly bring in their theory as one of geological probability.

In discussing the question,—When did the Mammoth live? or, rather,—When did he die out? much stress is laid upon the very few instances of its bones found in the peat, as well as on the condition of the remains in Siberia. It is affirmed that there is every mark of "recency" in connexion with these remains all over the world. Much also is made of the instances in which Palæolithic implements have been found lying together with Neolithic and bronze manufactures. Mr. Southall, without invalidating the succession assumed by Sir John Lubbock, Mr. Evans, and others, yet shows such overlapping as practically to annihilate the theory as a measure of general time. Certainly rude unpolished flints are found with polished stone, and both with bronze, and all with iron; but this fact is capable of the interpretation that relics of one period were still extant in the succeeding age, and that it is in the predominance and ultimate exclusive use that we are to look for the true index of events. Mr. Southall quotes Mr. E. B. Tylor as his authority for the illusory nature of the common divisions. He affirms that inasmuch as the Glacial Period in Scotland and Denmark lasted down to the polished-stone age, it is fair to argue that the Somme-valley deposits, belonging to the last glaciation, may not be very ancient. The most valuable inference in regard to this we find in the 32nd chapter, which details the observations and calculations of Dr. Edmund Andrews, President of the Chicago Academy of Science. In a remarkable paper on the North American Lakes, Dr. Andrews shows good cause for believing that their present outlines are post-glacial, and that "the total time of all the deposits (since the Glacial Period) appears to be somewhere between 5300 and 7000 years; and further, that the country has undergone changes of level since the Glacial Period." Dr. Andrews and Mr. Belt are at opposite poles.

We cannot fail to perceive that geologists are reducing their figures. We no longer hear of millions of years. The acute reviewer of the present book in the *Spectator* of November 27th, proposes 20,000 years as the duration of man on the earth. But in truth all positive statements of this kind are open to the same objections as are the smaller figures. We are not yet in a condition to measure the units, though we have advanced so far as to be able to say that the entire quantity *need* not be so long as was at one time conceived to be required by the evidence.

Every one who has watched the course of a long legal trial is well acquainted with the swaying to and fro of opinion during its pendency. We are still in this oscillating stage. Mr. Southall ably sums up as an advocate for recency. We shall have further evidence and a reply, and then, at some unknown future period, a competent judge will intervene and put the whole case impartially before the jury of public scientific opinion, and a true verdict will doubtless be given. Meanwhile we wait in the "*Salle de pas perdues.*"—S. R. P.

III.—The Potton and Wicken Phosphatic Deposits. Being the Sedgwick Prize Essay for 1873. By J. J. H. Teall, B.A., F.G.S. (Cambridge, Deighton, Bell & Co.; London, George Bell & Sons, 1875.)

THE Sedgwick Prize is given every third year for the best Essay on some subject in Geology, but the competition *is limited to the Graduates of the University of Cambridge who have resided within one mile and a half from the University Church for sixty days during the twelve months preceding the day on or before which the Essay must be sent in.* This is the first time that the Prize has been awarded, as no essay was sent in for the years 1867 and 1870.

The subject proposed was "The Potton and Wicken Phosphatic Deposits, and their general relation to the Necomian Strata of Western Europe, lying between the Portland Beds and the Gault." The publication of this Essay has been delayed to make the work more complete. The author in the first chapter gives a somewhat imperfect account of the "literature of the subject," which we need not notice, as most of the readers of this Magazine are quite familiar with these deposits. He next gives an account of the Potton deposit. The chief new points are a careful description of the pebbles, and an attempt to determine the species of the derived mollusca; the author also shows that an older Neocomian deposit has suffered denudation. As the workings at Wicken (Upware) are abandoned, Mr. Teall reprints the sections which were published in this MAGAZINE, and tries to determine the derived fossils. He next gives a list of the indigenous fossils contained in the Woodwardian Museum. We are sorry to differ from the author with regard to the Brachiopoda; he states that "it is more than probable that variable types have given rise to the unnecessary multiplication of species. Thus *T. microtrema, T. Dallasii*, and *T. Lankasteri* are possibly varieties of *T. prælonga* (Sow.); at least there are indications of transitional forms." This is more to be regretted, as the author has not corrected his list of Brachiopoda according to Mr. Davidson's Cretaceous Supplement: probably when he has consulted this work, he will modify his views on this subject. The author next gives a general sketch of the Neocomian deposits of Norfolk, Bedford, Cambridge and Buckingham; this has been carefully done, and contains many very interesting sections. He has not settled the question whether an old Neocomian (?) rock occurs in position under the bed of the river Cam between Upware and Ely. The author does not seem, however, to be aware of the valuable paper by Prof. Morris which appeared in the GEOL. MAG. Vol. IV. for 1867, p. 456. In concluding this branch of the subject, he reviews the Neocomian strata thus: "In Norfolk they are seen to consist of a threefold division, a loose sandy deposit at the base, resting unconformably on Kimmeridge-clay; next an argillaceous division, with ironstone nodules and fossils; and, lastly, true carstone, an indurated and highly ferruginous sandstone. The 'Carstone' in its turn appears to be conformably overlain by the 'Red Chalk,' and to pass gradually into that deposit." In tracing the deposits to the south, first the argillaceous division thins out, and also the overlying carstones, both of which seem to become subordinate to the loose sand series; the whole is gradually attenuated, and the conglomerate and pebble-beds are intercalated. The author rightly concludes from stratigraphical and palæontological considerations that the Potton and Upware deposits belong to the very latest part of the Neocomian period, and that their affinities are to be sought for in the Folkestone beds of the South of England.

Mr. Teall next briefly points out the probable relations of the Neocomian deposits of the central and eastern counties to the strata of Western Europe, lying between the Portland Beds and the Gault. He considers, with Prof. Phillips, that the fluviatile ironsands of Shotover, Brill, and Hartwell, belong to an older period than the marine sands of Seend, Farringdon, and Culham, near Oxford; and that the denudation of the older sands furnished much of the material for the Woburn and Potton series. We are disappointed that the author has not more fully considered the relations of these deposits to the foreign strata, and endeavoured to determine the age of the deposit at Essen, and of the Tourtia of Belgium, which have been referred to both the upper and the lower part of the Cretaceous formation. We quite agree with the author in considering the Upware, Potton, Farringdon, Godalming, Brickhill, and Folkestone beds, belong to the *same stage* as the Aptien of France and Switzerland. It may be deisable however to separate the English beds from the Lower Greensand, and to distinguish them as Aptian. The author, in conclusion, considers it probable that the pebbles of palæozoic and metamorphic rocks have been derived from the rocks which underlie the Chalk to the east, and which probably formed land during the Neocomian period. He next considers the origin of the phosphatic matter. We are glad he rejects the absurd theory that the waters were charged with phosphoric acid by the denudation of apatite, and accepts the view that the phosphoric acid was furnished by the decomposition of animal matter. Finally, he gives an account of what he conceives to have been the physical features of this area during the deposition of the strata in question, and also of the succession of events which immediately preceded their deposition. The author, in acknowledging his sources from whence his information has been derived, states that he did not see Mr. Meÿer's papers on this subject until he had arrived at the same conclusions independently. Although we cannot quite agree with Mr. Teall in a few minor points, yet we have much pleasure in recommending this interesting essay to the notice of the readers of this MAGAZINE.

I. F. W.

IV.—THE GEOLOGY OF CAMBERWELL.[1]

IN one of the chapters of the "History of Camberwell," recently published, Mr. A. Bott, F.G.S., has given an interesting account of the geological formations which have been observed within the parish. Previous notices of the geology have appeared by Mr. Allport,[2] Mr. Whitaker,[3] and other authors, all of which are referred to by Mr. Bott, whose contribution comprises not only detailed descriptions of the various sections and lists of the fossils collected within the district, but also some general inferences as to the conditions under which the strata were formed. The knowledge of the geological structure of this part of the London Basin has been much increased by the careful observation of the excavations made for the construction of the main line and effra branch of the Southern High Level Sewer. The formations noticed belong to the Quaternary and Eocene periods:—Post-Tertiary or Quaternary—beds of peat, brick-earth, sand, and gravel. Eocene—London-clay, Oldhaven beds, Woolwich beds, Thanet beds.

The sections exposed during the progress of the works for the sewer, as well as some others in the parish, are successively noticed, together with their lithological character. The Woolwich beds appear to be the best developed, and are interesting as presenting a difference in their mineral and fossil characters (chiefly the abundance of *Paludina*) to the equivalent strata at Lewisham, Charlton, etc.; still, however, indicating estuarine conditions, from the alternations of marine, fluvio-marine, and fresh-water forms of life. The fossils, including some new to science, are fairly numerous: there are remains of mammals, birds, reptiles, fish, mollusca, and traces of insects and plants. The mammals comprise *Coryphodon*, *Hyracotherium*, and a portion of a mandible, which Mr. W. Davies regards as belonging to a species of [illegible]. The overlying Oldhaven and Blackheath beds and London clay are noticed, and a list of the fossils obtained from the latter formation at Dulwich Wood and Sydenham Hill is furnished by Mr. Caleb Evans. Overlying the Eocene beds, in some parts, are sands, gravels, and clays, belonging or subsequent to the Glacial Period; and still newer than these are beds of peat, found in the lower part of the parish, which at that time, as well as the district towards the Thames, was more or less of a swampy character favourable to rapid vegetable growth; as the river became gradually restricted to its present limits by artificial means, the forest disappeared, leaving trunks and leaves to attest the last change in the physical conditions of this and other low-lying parts of the Thames near London. J. M.

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[1] The Parish of Camberwell, its History and Antiquities, by W. H. Blanch. London, 1875. Geology, pp. 9-27.

[2] Collections Illustrative of the Geology of Camberwell.

[3] Geology of London Basin, Mem. Geol. Surv.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.—I.—November 17, 1875.—John Evans, Esq., V.P.R.S., in the Chair.—The following communications were read:—

1. "On a new modification of Dinosaurian Vertebræ." By Prof. Richard Owen, C.B., F.R.S., F.G.S., etc.

The peculiar modification of the Dinosaurian vertebra noticed by the author occurs in *Tapinocephalus Atherstonii* and *Pareiosaurus bombidens*. In the dorsal vertebræ of the former the centra are nearly flat on both fore and hind surfaces, a structure to express which the author proposes the term "amphiplatyan." The hind surface is very slightly the more concave. The middle of each surface is pierced by a small foramen leading into a cylindrical canal, first slightly expanding and then rapidly contracting to a point, which meets the apex of the similar hollow cone coming from the opposite surface. Similar characters were observed upon the free surface of the anterior sacral and upon that of the posterior of four anchylosed sacrals.

The dorso-lumbar vertebræ of the *Pareiosaurus* had centra relatively longer than those of *Tapinocephalus*. Their articular surface is subundulate, convex along a fourth of the periphery, concave at the centre, where there is an excavation corresponding to that in *Tapinocephalus*, but a relatively wider aperture, a rather more constricted canal, a shorter terminal cone, and an interval of osseous tissue separating the apices of the cones from the fore and hind surfaces. In what is probably the first cervical vertebra of the same Dinosaur, the centrum is so concave on both surfaces as to become amphicœlian.

In these unossified tracts of the middle of the centrum in the two genera above mentioned the author sees indications of a persistent of the primitive “chorda dorsalis”; and he calls attention to semblance thus set up between these probably Triassic Dino- and the lower Ganocephalous reptiles of the Carboniferous , in which, however, the vertebral centra are more widely rated.

“On the Presence of the Forest-bed Series at Kessingland and field, in Suffolk, and its position beneath the Chillesford Clay.” ohn Gunn, Esq., M.A., F.G.S.

this paper the author described a section from the cliff at ngland and Pakefield, from the examination of which he ed at the conclusion that the Forest-bed series underlies the esford Clay and Sands. At the foot of the cliff there is an rine deposit forming the soil of the Forest-bed, consisting of clay and gravel, the “Elephant-bed” of the author's former r. Above this is the Forest-bed, containing large stools and of trees, but no fossil bones. This is followed by a freshwater it, consisting of black soil with freshwater shells, corresponding similar bed at Mundesley and Runton, known as the “*Unio*- and including the “Rootlet-bed” of oozy clay, regarded by Prestwich as an indication of the forest. The author considers upposed rootlets to represent brushwood which succeeded the forest. Above this come Fluvio-marine deposits, in which Crag- occur although but rarely. To this division the author was ed to refer the Norwich Crag, which at Bramerton underlies ext division, regarded by the author as the Chillesford Clays ands. Of the overlying deposits the first is supposed to be the bly-bed” by the author; it has been regarded as Middle Drift, he uppermost is Upper Boulder-clay. The paper was illustrated e exhibition of a fine series of bones, chiefly Cervine, from the t deposit noticed by the author.

—December 1st, 1875.—John Evans, Esq., V.P.R.S., President, Chair. The following communication was read:—

On the Granitic, Granitoid, and associated Metamorphic Rocks he Lake-district.” Parts III., IV., and V. By J. Clifton l, Esq., F.G.S., of the Geological Survey of England and s.

rt III.—*On the Skiddaw Granite and its associated Metamorphic s.*

e subject was treated under the three heads of (1) *Examination Field*, (2) *Microscopical Examination*, (3) *Chemical Examination*, he following were the general results arrived at. The meta- hism of the Skiddaw Slate extends for many miles around the al granitic masses, and commences by the formation of small which become developed into chiastolite crystals. The chias- *slate* passes into spotted *schist*, by the great increase of the oblong spots arranged along planes of foliation, and mica ap- . The spotted schist graduates into mica schist, which, however, retains to the last faint spots, and occasionally chiastolite crystals. The junction between the mica-schist and the granite is generally rather abrupt. On the whole, chemical and field evidence especially are *against* regarding the granite, now exposed, as the result of the extreme metamorphism of the Skiddaw slates *immediately* around it; but whether it may not have resulted from the metamorphism of underlying parts of the same series is an open question. The great contortion of the mica-schist around the granitic centres may be in part due to the, at any rate, *partially* intrusive character of the granite.

In an Appendix abstracts of papers by various authors who have written in connexion with the subject were given.

Part IV.—*On the Quartz Felsite, Syenitic, and associated Metamorphic Rocks of the Lake-district.*

This part was treated under the same three heads of *Field, Microscopical,* and *Chemical* evidence as the last.

The Quartz Felsite of St. John's Vale, and the Syenitic Granite of Buttermere and Ennerdale, lie for the most part at the junction of the volcanic and Skiddaw series, and seem by their line of strike, and by the occasional presence of bands of slate or volcanic rock, enclosed within or running through them, to represent the transition beds between the two series, metamorphosed in great measure *in situ.* Both microscopic and chemical evidence demonstrate the possibility of this process.

Evidence gathered in the field, and microscopic and chemical examination, all seem to suggest that the rocks of Carrock Fell, etc., represent the base of the volcanic series, consisting largely of contemporaneous traps, thrown into a synclinal, the axis of which ranges generally east and west, and metamorphosed into rocks of greatly varying character, such as sphærolitic felsite, hypersthenite, and diorite.

Although all the various masses treated of were probably formed in the main by the metamorphism of beds *in situ,* it is probable that some parts of the resulting magma became occasionally intrusive among and absorptive of higher beds.

In an Appendix notices of papers on these rocks by other authors were given.

Part V.—*General Summary.*

In this part the leading results of the four preceding divisions of this memoir were briefly brought forward, followed by the discussion of various considerations relating to metamorphism, under the following heads:—(1) Granite at various depths; (2) how far granite may be an ultimate universal product of metamorphism; (3) distribution of metamorphism (selective metamorphism); (4) classes of metamorphism.

The paper was illustrated by a large geological map of the northern part of the Lake-district, by a geological model of the Keswick district, by rock specimens, and large coloured photographs taken from water-colour microscopic drawings made by the author.

CORRESPONDENCE.

E ON RANGE OF *SACCAMMINA CARTERI*, BRADY, IN THE CARBONIFEROUS SERIES.

R,—In his paper "On the Limits of the Yoredale Series in the th of England,"[1] Mr. Lebour says, in a footnote: "Up to the ent time the well-marked foraminifer *Saccammina Carteri*, Brady, pparently limited to a bed in the Upper or Yoredale part of the es, viz. the Four-fathom Limestone." Mr. Lebour seems to be ware of the fact that *S. Carteri* has been found plentifully in Scot- l in the limestones at the bottom of the Carboniferous Series. In Appendix to the Explanation of Sheet 23,[2] Mr. R. Etheridge, , says, page 96: "In the Midlothian Carboniferous Series one he collectors of the Geological Survey, Mr. J. Bennie, has lately d Foraminiferæ at several localities rather abundantly. The rrence of *Saccammina Carteri* has also been proved by the same ector at no less than eight localities in the Lower Limestone up, viz. at Mount Lothian, Fullarton, Crichton Magazine, ridee and Middleton Quarries, Bood's Mill, and No. 16 Mine, rwell, Edinburghshire. *S. Carteri* was also obtained some s ago by the Geological Survey at the Cat Craig, Dunbar."

Etheridge alludes in the last sentence to specimens of *Saccam- a* limestone collected by the Survey collector Mr. R. Gibbs, er shortly before or after 1858. These specimens may be seen he Museum of Practical Geology, Jermyn Street, and also in Survey Collection, Museum of Science and Art, Edinburgh. In Jermyn Street Catalogue of Fossils, published 1865, page 117, he following entry: "Foraminifera in Limestone; Cat Craig, bar," from which I infer that Mr. Salter had prior to that date gnized this fossil to be a Foraminifer.

n 1874 I found the same fossil at Kidlaw, Haddingtonshire, in the Lower Limestones, and this year (June, 1875) at Donken rry, Dumfriesshire, in a limestone much lower down than any of limestones above referred to, viz. in the Calciferous Sandstones, what Mr. Lebour calls the Tuedian Rocks.

Ir. John Young, in a paper "On the Occurrence of *Saccammina teri*, Brady, in the Limestone Series of Lanarkshire," read il, 1872, published in the Trans. Geol. Soc. Glasgow, vol. iv. 63, records the finding by himself of fragments of limestone in ich were "abundance of small spherical spots of white carbonate lime, which in 1872 he recognized as *Saccammina Carteri*;" and her adds, the same Foraminifer has been found by Mr. Hunter in Main Limestone, Carluke. These limestones are the lowest of Carboniferous Series.

'rom these facts Mr. Lebour will see that *S. Carteri* is not limited he Upper or Yoredale Rocks, but has a much lower range, being tiful in the lowest beds of the Carboniferous Series, and has n found even far down in the Calciferous Sandstone Series.

JAMES BENNIE.

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[1] GEOL. MAG. Nov. 1875, p. 543.

[2] Memoirs Geol. Surv. *Scot., published* Nov. 1873.

BOS PRIMIGENIUS IN ALGERIA.

Sir,—I have just received information from my friend M. Durando of Algiers, of the discovery of the entire head with enormous horn-cores of a fossil ox at Djelfa, on the Hautes Plateaux of Algeria, supposed to be *Bos primigenius* (?).

The skull in the Museum at Algiers, discovered some years ago at Bab-Azzoun, near Algiers, has, I believe, been determined as *Bubalus antiquus*. The skull from Djelfa has also been placed in the Museum, and should be examined by any palæontologist visiting Algiers, with a view to the correct determination of the species.

Djelfa is a fortress about 150 miles south of Algiers, situated on the military road connecting Algiers with L'Aghouat, at a height of 2600 feet. G. Maw.

Benthall Hall, near Broseley.

OBITUARY.

NATHANIEL T. WETHERELL, M.R.C.S., F.G.S.

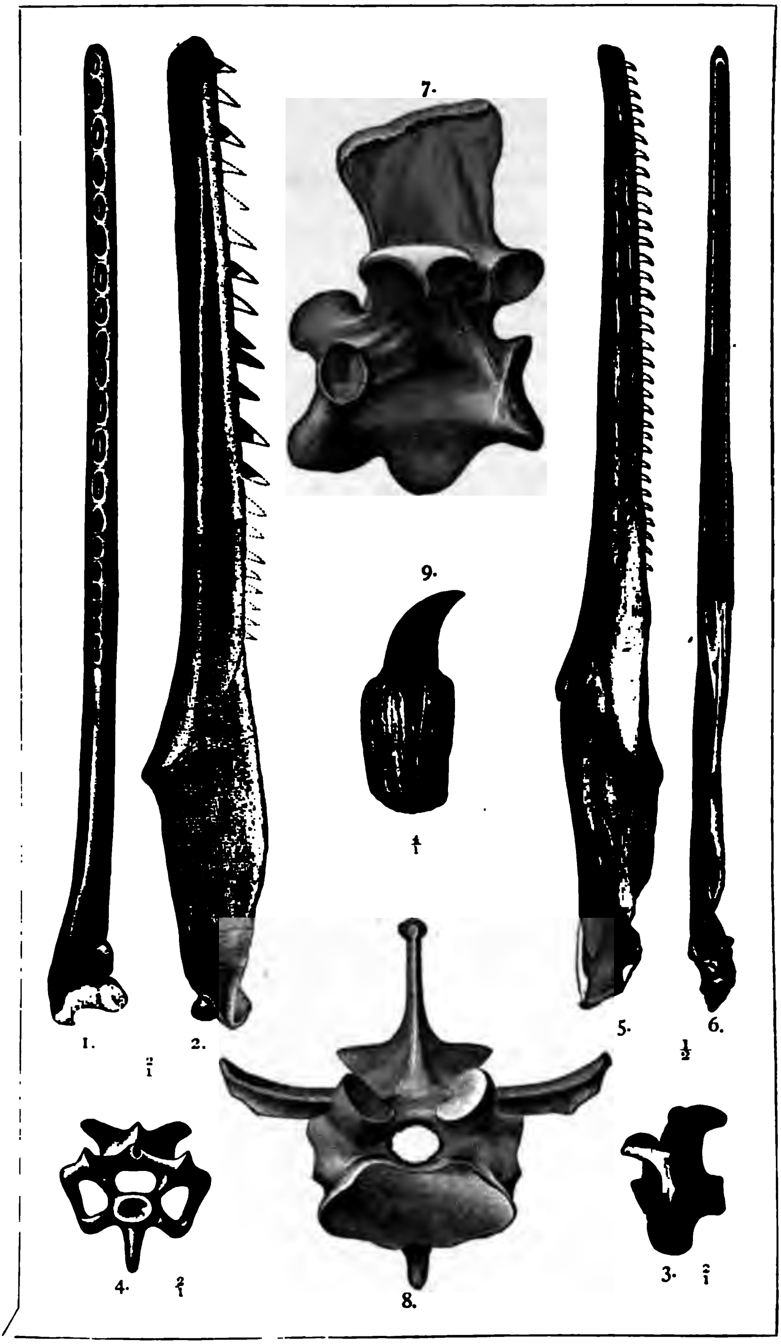
The closing year has taken with it another member of the old "London Clay Club," Mr. N. T. Wetherell, who died at his residence at Highgate on the 22nd December, 1875, aged 75 years. Like his friend F. E. Edwards, whose death we noticed last November, Mr. Wetherell devoted his attention specially to the study of the fossils of the London Clay (particularly those from localities on the north of London): but he had besides given much time to the careful collection of the fossils from the Glacial Drift-deposits of Finchley and Muswell Hill. The latter collection is preserved in the Museum of Practical Geology, Jermyn Street, whilst the greater portion of his very extensive London Clay Collection has been secured for the Brit. Mus.

The following is a list of Mr. Wetherell's chief scientific papers :—

1. Observations on the London Clay of Highgate Archway, Proc. Geol. Soc. Lond., vol. i. June 19, 1822, p. 403.
2. On an *Ophiura* found at Child's Hill, N.W. of Hampstead, op. cit., p. 417. Jan. 9, 1833.
3. Observations on a Well dug at the Lower Heath on the South Side of Hampstead. (June, 1834.) Trans. Geol. Soc., vol. v. 1840, p. 131.
4. A Notice of some Organic Remains recently discovered in the London Clay, Proc. Geol. Soc. Lond., vol. iii. p. 140.
5. On the Occurrence of *Graphularia Wetherellii*, in Nodules from the London Clay and the Crag, 1859, Quart. Journ. Geol. Soc., vol. xv. p. 30.
6. On the Structure of some of the Siliceous Nodules of the Chalk, 1859, op. cit., vol. xv. p. 193.

Besides the above, Mr. Wetherell communicated numerous notes on geological and palæontological subjects to "Loudon's Magazine of Natural History," the "Annals," the "Geologist," the "Geological Magazine," and other scientific journals. He paid much attention to the investigation of "the Banded Structure seen in Flints." (See an article by Dr. S. P. Woodward, Geol. Mag. 1864, Vol. I. p. 145, Pl. VII. and VIII.)

Mr. Wetherell was one of the earliest Fellows of the Geological Society of London, and although of late years he ceased to attend its meetings, he continued to the last devotedly attached to geological science, which through his long life he earnestly endeavoured to promote. Both in his profession as a medical man, and also among his scientific friends, he was warmly esteemed. W.



BIRDS WITH TEETH.

s. *1-4. Ichthyornis dispar*, Marsh. FIGS. 5-9. *Hesperornis regalis*, Marsh.

THE
GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE II. VOL. III.

No. II.—FEBRUARY, 1876.

ORIGINAL ARTICLES.

I.—On the Odontornithes, or Birds with Teeth.[1]

By Professor O. C. Marsh, M.A., F.G.S.,
Of Yale College, Newhaven, Ct. U.S.A.

(PLATE II.)

REMAINS of birds are among the rarest of fossils, and few have been described save from the more recent formations. With the exception of *Archæopteryx* from the Jurassic, and a single species from the Cretaceous, no birds are known in the old world below the Tertiary.[2] In this country, numerous remains of birds have been found in the Cretaceous, but there is no satisfactory evidence of their existence in any older formation, the three-toed footprints of the Triassic being probably all made by Dinosaurian reptiles.

The Museum of Yale College contains a large series of remains of birds from the Cretaceous deposits of the Atlantic coast and the Rocky Mountain region, thirteen species of which have already been described by the writer. The most important of these remains, so far as now known, are the *Odontornithes*, or birds with teeth, and it is the object of the present communication to give some of the more marked characters of this group, reserving the full description for a memoir now in course of preparation.

The first species of birds in which teeth were detected was *Ichthyornis dispar*, Marsh, described in 1872.[3] Fortunately the type specimen of this remarkable species was in excellent preservation, and the more important portions of both the skull and skeleton were secured. These remains indicate an aquatic bird, fully adult, and about as large as a pigeon.

The skull is of moderate size, and the eyes were placed well forward. The lower jaws are long, rather slender, and the rami were not coössified at the symphysis. In each lower-jaw there are twenty-one distinct sockets, and the series extends over the entire upper margin of the dentary bone (Plate II. Figures 1 and 2). The teeth in these sockets are small, compressed and pointed, and all are directed more or less backward. The crowns are covered with nearly smooth enamel. The maxillary teeth appear to have been numerous, and essentially the same as those in the mandible. Whether the premaxillary bones supported teeth, or were covered with a horny beak, cannot be determined from the present specimen.

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[1] From the American Journal of Science and Arts, vol. x. Nov. 1875.

[2] For some account of previously known Fossil Birds, see an Article on "Birds with Teeth," by H. Woodward, in the "Popular Science Review," No. 57, October, 1875, p. 337, pl. cxxv.

[3] Silliman's American Journal, vol. iv. p. 344, and vol. v. p. 74.

The scapular arch and the bones of the wings and legs all conform closely to the true avian type. The sternum has a prominent keel, and elongated grooves for the expanded coracoids. The wings were very large in proportion to the legs, and the humerus had an extended radial crest. The metacarpals are coössified, as in recent birds, thus differing widely from those of *Archæopteryx*. The bones of the posterior extremities are slender, and resemble those of some aquatic birds. The centra of the vertebræ are all biconcave, the concavities at each end being distinct, and nearly equal (Plate II. Figures 3 and 4). The sacrum is elongated, and made up of a large number of coössified vertebræ. Whether the tail was elongated or not cannot at present be decided.

The jaws and teeth of this species show it to have been carnivorous, and it was probably aquatic. Its powerful wings indicate that it was capable of prolonged flight.

Another Cretaceous bird (*Apatornis celer*, Marsh), belonging apparently to the same order as *Ichthyornis*, was found by the writer in 1872 in the same geological horizon in Kansas.[1] The remains preserved indicate an individual about the same size as *Ichthyornis dispar*, but of more slender proportions. The vertebræ are biconcave, and there were probably teeth.

The most interesting bird with teeth yet discovered is perhaps *Hesperornis regalis*, a gigantic diver, also from the Cretaceous of Kansas, and discovered by the writer in 1870. The type specimen, which was found by the writer in 1871, and described soon after, consisted mainly of vertebræ and the nearly complete posterior limbs, all in excellent preservation.[2]

A nearly perfect skeleton of this species was obtained in Western Kansas by Mr. T. H. Russell and the writer in November, 1872, during the explorations of the Yale College party, and several other less perfect specimens have since been secured, and are now in the Yale Museum. These various remains apparently all belong to one species.

The skull of *Hesperornis* has the same general form as that in *Colymbus torquatus*, Brün., but there is a more prominent median crest between the orbits, and the beak is less pointed. The brain cavity was quite small. The maxillary bones are massive, and have throughout their length a deep inferior groove which was thickly set with sharp, pointed teeth. These teeth had no true sockets, but between their bases there are slight projections from the sides of the grooves. (Plate II. Figure 6.) The teeth have pointed crowns, covered with enamel, and supported on stout fangs. (Plate II. Figure 9.) In form of crown and base, they most resemble the teeth of Mosasauroid reptiles. The method of replacement, also, was the same, as some of the teeth preserved have the crowns of the successional teeth implanted in cavities in their fangs. The maxillary grooves do not extend into the premaxillaries, and the latter do not appear to have supported teeth. The external appearance, moreover, of the premaxillaries seems to indicate that these bones were covered with a horny bill, as in modern birds.

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[1] Silliman's American Journal, vol. v. p. 74, Jan. 1873.

[2] Silliman's American Journal, vol. iii. p. 360, May, 1872.

The lower jaws are long, and slender, and the rami were united in front only by cartilage. The dentary bone has a deep groove throughout its entire length, and in this, teeth were thickly planted, as in the jaws of *Ichthyosaurus*. The lower teeth are similar to those above, and all were more or less recurved. (Plate II. Figure 5.) These grooves contain slight projections from the sides, but there are no true sockets. (Plate II. Figure 6.)

The scapular arch of *Hesperornis* presents many features of interest. The sternum is thin and weak, and *entirely without a keel.* In front, it resembles the sternum of *Apteryx*, but there are two very deep posterior emarginations, as in the Penguins. The scapula and coracoid are very small. The wing bones are diminutive, and the wings were rudimentary, and useless as organs of either flight or swimming.

The vertebræ in the cervical and dorsal regions are of the true ornithic type, the articular faces of the centra being quite as in modern birds. (Plate II. Figures 7 and 8.) The sacrum is elongated, and resembles that in recent diving birds. The last sacral vertebra is quite small. The caudal vertebræ, which are about twelve in number, are very peculiar, and indicate a structure not before seen in birds. The anterior caudals are short, with high neural spines and moderate transverse processes. The middle and posterior caudals have very long and horizontally expanded transverse processes, which restrict lateral motion, but clearly indicate that the tail was moved vertically, probably in diving. The last three or four caudal vertebræ are firmly coössified, forming a flat terminal mass, analogous to, but quite unlike, the "ploughshare" bone of modern birds. The anterior two at least of these caudals have expanded transverse processes.

The pelvic bones, although avian in type, are peculiar, and present some well-marked reptilian features. A resemblance to the corresponding bones of a Cassowary is at once evident, especially in a side view, as the ilium, ischium, and pubis all have their posterior extremities separate. The two latter are slender, and also free back of their union with the ilium at the acetabulum. The ischium is spatulate at its distal end, and the pubis rodlike. The acetabulum differs from that in all known birds, in being closed internally by bone, except a foramen, that perforates the inner wall.

The femur is unusually short and stout, much flattened anteroposteriorly, and the shaft curved forward. It somewhat resembles in form the femur of *Colymbus torquatus*, Brün., but the great trochanter is proportionally much less developed in a fore-and-aft direction, and the shaft is much more flattened. The tibia is straight and elongated. Its proximal end has a moderately developed cnemial process, with an obtuse apex. The epi-cnemial ridge is prominent, and continued distally about one-half the length of the shaft. The distal end of the tibia has on its anterior face no ossified supratendinal bridge, differing in this respect from nearly all known aquatic birds. The fibula is well developed, and resembles that of the Divers. The patella is large, as in *Podiceps*, and in position extends far above the elevated rotular process of the tibia.

The tarso-metatarsal bone is much compressed transversely, and resembles in its main features that of *Colymbus*. On its anterior face there is a deep groove between the third and fourth metatarsal elements, bounded on its outer margin by a prominent rounded ridge, which expands distally into the free articular end of the fourth metatarsal. This extremity projects far beyond the other two, and is double the size of either, thus showing a marked difference from any known recent or fossil bird. There is a shallow groove, also, between the second and third metatarsals. The second metatarsal is much shorter than the third or fourth, and its trochlear end resembles in shape and size that of the former. The existence of a hallux is indicated by an elongated oval indentation on the inner margin above the articular face of the second metatarsal. The free extremities of the metatarsals have the same oblique arrangement as in the *Colymbidæ*, to facilitate the forward stroke of the foot through the water. There are no canals or even grooves for tendons on the posterior face of the proximal end, as in the Divers and most other birds; but below this, there is a broad, shallow depression, extending rather more than half way to the distal extremity.

The phalanges are shorter than in most swimming birds. Those of the large, external toe are very peculiar, although an approach to the same structure is seen in the genus *Podiceps*. On the outer, inferior margin, they are all deeply excavated. The first, second, and third have, at their distal ends, a single, oblique, articular face on the inner half of the extremity, and the outer portion is produced into an elongated, obtuse process, which fits into a corresponding cavity in the adjoining phalanx. This peculiar articulation prevents flexion except in one direction, and greatly increases the strength of the joints. The terminal phalanx of this toe was much compressed. The third, or middle, toe was greatly inferior to the fourth in size, and had slender, compressed phalanges, which correspond essentially in their main features with those of modern Divers.

The remains preserved of *Hesperornis regalis* show that this species was larger than any known aquatic bird. All the specimens discovered are in the Yale College Museum, and agree essentially in size, the length from the apex of the bill to the end of the toes being between five and six feet. The habits of this gigantic bird are clearly indicated in the skeleton, almost every part of which has now been found. The rudimentary wings prove that flight was impossible, while the powerful swimming legs and feet were peculiarly adapted to rapid motion through the water. The tail appears to have been much expanded horizontally, as in the Beaver, and doubtless was an efficient aid in diving, perhaps compensating in part for want of wings, which the Penguins use with so much effect in swimming under water. That *Hesperornis* was carnivorous is clearly proven by its teeth; and its food was probably fishes.

zoological position of *Hesperornis* is evidently in the *Odon-*
s; but the insertion of the teeth in grooves, the absence of a
the sternum, and the wide difference in the vertebræ require
be placed in a distinct order, which may be called *Odontolcæ*,
sion to the position of the teeth in grooves.

two orders of birds with teeth would then be distinguished
ws :—

Sub-class, ODONTORNITHES (or AVES DENTATÆ).

eeth in sockets. Vertebræ biconcave. Sternum with keel. Wings well developed. Order, ODONTOTORMÆ.

eeth in grooves. Vertebræ as in recent birds. Sternum without keel. Wings rudimentary. Order, ODONTOLCÆ.

omparing *Ichthyornis* and *Hesperornis*, it will be noticed that
nbination of characters in each is very remarkable, and quite
erse of what would naturally be expected. The former has
n distinct sockets, with biconcave vertebræ; while the latter
eth in grooves, and yet vertebræ similar to those of modern
In point of size, and means of locomotion, the two present
st marked contrast. The fact that two birds, so entirely dif-
living together during the Cretaceous, should have been re-
d in such perfect preservation, suggests what we may yet
learn of life in that period.

geological horizon of all the *Odontornithes* now known is the
Cretaceous. The associated vertebrate fossils are mainly
uroid reptiles and Pterodactyls.

ull description with plates of all the known *Odontornithes* is
being prepared by the writer.

LE COLLEGE, NEW HAVEN, *Oct.* 18*th*, 1875.

EXPLANATION OF PLATE II.

s. 1–4. *Ichthyornis dispar*, Marsh. Twice natural size.
  FIG. 1. Left lower jaw; top view.
  „ 2. Left lower jaw; side view.
  „ 3. Cervical vertebra; side view.
  „ 4. Same vertebra; front view.
s. 5–9. *Hesperornis regalis*, Marsh.
  FIG. 5. Left lower jaw; side view; half natural size.
  „ 6. Left lower jaw; top view; half natural size.
  „ 7. Dorsal vertebra; side view; natural size.
  „ 8. Same vertebra; front view; natural size.
  „ 9. Tooth; four times natural size.

II.—CONTRIBUTIONS TO THE STUDY OF VOLCANOS.

By JOHN W. JUDD, F.G.S.

SECOND SERIES.—THE ANCIENT VOLCANOS OF EUROPE.

e preceding chapters we have endeavoured to throw light upon
me of the more salient characters of volcanos—the features
ir architecture, the nature of their products, and the peculiari-
their attendant phenomena. In doing so, however, we have
red to select our illustrations from some of the less familiar,
, as we hope to have shown, by no means less interesting
os of our continent; and have of set purpose avoided the

oft described examples of Vesuvius, Etna, the Auvergne, and the Eifel.

Before we turn our attention to the evidences which are found of the existence of volcanos in the same area during former geological periods, it will be instructive to pause, in order to take a brief review of the existing distribution of volcanic agencies in Europe.

Excluding Iceland, there are in Europe five volcanos known to be still active. One of these, Stromboli, is in a state of permanent eruption, while the other four—Etna, Vesuvius, Vulcano, and Santorin—may be the seat of a paroxysmal outburst at any moment. To these we ought perhaps to add the *mud-volcanos* of Sicily, Transylvania, and Wallachia. Some other volcanos, like the Solfatara of Naples and the Büdos Hegy in Transylvania, still discharge considerable quantities of heated gas and vapour, and are presumed (though perhaps erroneously) to be approaching the stage of complete extinction. Nor, in taking a survey of the volcanic phenomena of Europe, ought we to omit to notice those innumerable sources of hot water and gas, which perhaps collectively relieve the earth's crust of more heat than escapes from it during all the outbursts of volcanic violence, though in a manner so much less impressive. These hot springs, rising probably in the lines of old volcanic fissures, have determined the positions of the health-resorts which are found in such abundance in certain parts of the Continent.

But a large number of mountains and hills exist in Europe, which, although exhibiting few, if any, symptoms of igneous activity at the present time, yet in their structure and materials present so many points of analogy with the active volcanos which we have enumerated, that no one can for a moment hesitate in assigning to them a similar mode of origin. Such are the innumerable extinct volcanos in the districts of Southern and Central Italy, the Auvergne, the Eifel, the Grecian Archipelago, the Island of Sardinia, and that lying on both sides of the eastern end of the chain of the Pyrenees. Besides these, several more isolated volcanic cones exist in Europe, such as that of Orgiofhof in Moravia, and the well-known Kammerbühl and Eisenbühl in Bohemia. Among these extinct volcanos every possible gradation may be traced, from such as present the most perfect and unweathered cones and craters, the complete extinction of some of which (as, for example, those of the Campi Phlegræi and Ischia) we are by no means assured of, to mere shapeless heaps of volcanic materials.

Besides the active and extinct volcanos, however, there are many masses of rock in Europe which in character and composition betray unmistakable evidences of their igneous origin; such are the so-called "traps" and many of the granitic rocks. Although the connexion of these with volcanic, or indeed with any kind of igneous action, was long strenuously denied, yet a more complete knowledge of such rocks, and a juster conception of the true nature of volcanic action, has now removed all doubts upon the subject from the minds of geologists, who now recognize and reason upon the evidences of *volcanic activity in* the earlier periods of the world's history with no *less certainty than* concerning those of the present day.

As illustrating the stages by which geologists have been gradually led to the adoption of their present views, we cannot perhaps do better than to relate "the story of the Kammerbühl."

The Kammerbühl, or Kammerberg (see Fig. 1), which is situated a little west of the road leading from the ancient town of Eger to the modern health-resort of Franzenbad in Bohemia, and about a mile and a half from both places, was styled by Goethe "a pocket edition of a volcano." The interest which this object has excited among geologists arises neither from its magnitude nor from the perfection of its preservation, for in both these respects it is surpassed by hundreds of volcanic cones which might be mentioned in Italy, the Auvergne, and the Rhineland. But from its position, almost in the midst of the camp of the Wernerian school, it has been the object of many a fierce controversy, and it enjoys the probably unique distinction of being a volcanic cone of which the internal structure has actually been demonstrated by means of mining operations carried on within and around it.

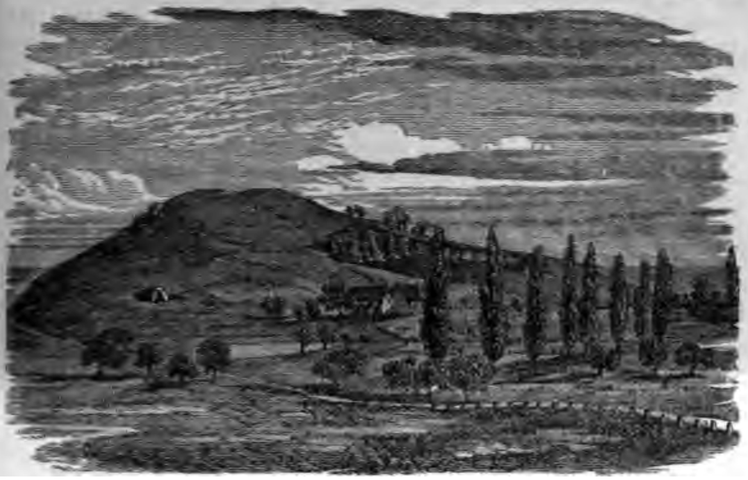

FIG. 1.—The Kammerbühl or Kammerberg, Bohemia, as seen from the South-west.

The word "bühl" is an archaic German one, signifying a low hill, the distinctive appellation being derived from the district in which it is situated—the Kammerwald. The Kammerbühl stands upon a plateau composed of mica-schist with much quartz, the surface of which is about 1500 feet above the sea-level. The hill itself is a very small one, with gentle slopes, its elevation above the surrounding plain being only 126 feet; but it is conspicuous on account of its isolation. Its base is enveloped and concealed by the thick superficial deposits of recent date, for at no very distant period the whole country round must have formed a series of vast lakes and morasses, many portions of which are still undrained. The base of the hill is an irregular oval in form, about 500 yards long and

200 yards broad; and we can perhaps best give an idea of its true character by describing it as a slightly-curved ridge of cinders, stretching from north-west to south-east, in the former of which directions it presents its greatest elevation and steepest slopes, while in the latter it gradually and almost insensibly sinks into the plain.

On ascending the hill, it is at once seen to be composed of basaltic scoriæ, often containing olivine, mingled with larger or smaller quantities of fragments of the mica-schist and quartz of the platform on which it stands. But the best idea of the structure of the hill is obtained by means of the large artificial excavation that has been made in its southern part. This is a quarry about 200 feet long, 80 feet wide, and 30 feet deep, from which the scoriæ are dug for covering the roads. It is known as the Zwergeloch (Pigmies' Hole) from the tradition that it is the scene of nightly assemblies and revels of the dwarfs.

The sides of this quarry exhibit beautiful sections showing that the mass of the hill is composed of basaltic scoriæ of remarkably fresh appearance; but scattered among these are angular fragments of clay-slate, mica-schist, and quartzite, often exhibiting a burnt appearance, and not unfrequently of a bright-red colour. The whole mass is beautifully stratified (as is so commonly the case with the materials of volcanic cones), the varying colours of the different bands giving rise to a very striking appearance. Occasional beds occur, of varying thickness, which are almost wholly composed of fragments of the subjacent rocks; these we may refer without doubt to the action of sudden explosions tearing away the sides of the vent. Many of the scoriæ entangle numerous small fragments of the metamorphic rocks, but the proportion of these entering into the composition of the cone is not nearly so great as in the case of many of the Eifel. The scoriæ vary in size from that of a pea, or even less, up to a yard in diameter. A few well-formed "bombs" occur, but do not constitute any large part of the whole, which consists mainly of very rugged scoriæ. A number of small faults or

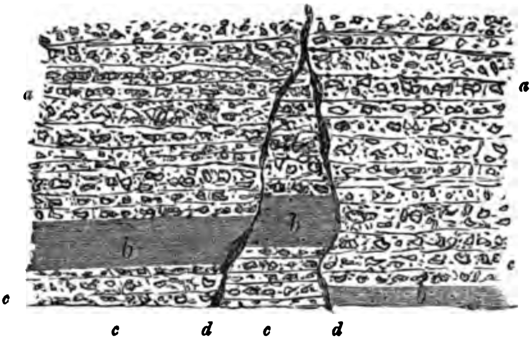

Fig. 2.—Section seen in side of the Zwergeloch.

a, *a*. Stratified Basaltic scoriæ.
b, *b*. Bands made up of fragments of burnt slate.
c, *c*. Stratified Basaltic scoriæ.
d, *d*. Pseudo-dykes occupying lines of fault.

es in the mass, an interesting example of which is represented
ig. 2, bear witness to the violence of the subterranean forces;
the appearance of chemical action on the materials near these
ther vertical fissures indicates that they once served as channels
he escape of gases and vapours (fumaroles). Some of these
ures are occupied by loose materials and constitute *pseudo-dykes*,
those so frequently seen in the Neapolitan volcanos.

the highest summit of the Kammerbühl there exists a small
depression, about 15 yards in diameter and 7 feet deep. It has
supposed to represent the "crater" of the volcano; but this
ion is certainly erroneous, and there is no doubt that the de-
sion in question has been occasioned by one or other of the
erous excavations which have been carried on in this hill, either
the purpose of discovering mineral treasures, or of satisfying
tific doubts. It is clear that the volcano of the Kammerbühl
suffered greatly from denuding causes, and that all its *external*
ures have been long destroyed. From what remains I should be
o infer that a series of several cinder cones in close apposition
inally existed here, and that the one at the north-west end,
h was the largest, was breached by a lava-stream.

he remains of this lava-stream are very clearly seen on the
tern side of the highest part of the ridge; its surface is highly
iaceous, and only some of the more rugged portions rise above
grass-grown slopes of the hill. The remains of a quarry, from
ch rock was at one time obtained (it is said for millstones, and
ainly for building purposes, as shown by the Roman tower in the
Castle of Eger), are seen in the midst of this lava-stream. By
ns of it we are enabled to see that the central and more solid
s of the lava constitute a true basalt, with much magnetite and
ine. This lava-stream cannot be traced far, and it appears to
e been one of those of very imperfectly liquid character, adhering
he sides of the cone, but not extending itself on the level ground
nd it.

rom the above brief description of the Kammerbühl, the reader
perhaps conclude that its true volcanic character is so obvious
no competent observer can ever have entertained a doubt upon
node of origin. Such, however, is very far from having been the
. Although, as early as 1773, the Ritter von Born, in a series of
ers to the Count von Kinsky, described the Kammerbühl as "an
nct volcano,"—yet the mischievous influences of the teachings of
rner subsequently manifested themselves in many attempts to
ve that the lava of the Kammerbühl was, in common with the
er patches of basaltic rock in Bohemia, "a floetz-trap rock," and
product of "aqueous precipitation."

n 1792 F. A. Reuss (the father of the recently deceased dis-
uished geologist A. E. Reuss) found the evidences of the action
ire in the materials of the Kammerbühl so overwhelming, as to
him to put forward a new theory of its mode of origin. He
ed that it was really the result of an "Erdbrand,"—a pheno-
on of not uncommon occurrence in Bohemia, and resulting from

spontaneous combustion taking place in beds of pyritous brown coal It is of course unnecessary to point out the utter futility of such a mode of explanation; nothing, indeed, but the most desperate determination to escape, at all hazards, from the admission of anything like volcanic action, could have led to its being entertained even for one moment.

In the midst of the controversies of which the Kammerbühl had thus become the centre, it is to the illustrious Goethe, whose philosophic mind so successfully grappled with some of the most difficult problems of comparative anatomy, botany, and other sciences that geologists are indebted for an able and independent examination of the whole question.

In 1809, and again in 1820, Goethe visited the Kammerbühl, and the result of his studies, as given both in Leonhard's Taschenbuch and the "Morphologie," was to place its true volcanic character beyond question. Subsequent writers on the subject, the list of which includes the names of Heinrich and Bernhard Cotta, Goldfuss Bischof, Berzelius, Ehrenberg, Leonhard, Nöggerath, Sternberg, A E. Reuss, and Jokely, have fully confirmed the correctness of the views maintained by Goethe.

But the most interesting part of the great German poet's contribution to this subject is that in which he suggested a simple means for removing once for all the doubts concerning the true origin of the Kammerbühl, and at the same time of applying to the Wernerian doctrines an infallible test. He showed that if, as "the Vulcanists" maintained, the basalt of the Kammerbühl came *from below*, a consolidated duct of the same material would probably be found in the midst of the cinder cone; and he suggested that mining operations should be carried on in the hill to confirm or disprove the presence of such a central core of basalt.

In 1834 the Count Caspar von Sternberg, whose contributions to fossil botany are so well known to geologists, determined to carry out the poet's suggestions. Already shafts and galleries had been sunk, in and around the Kammerbühl, with a view to the discovery of beds of brown coal. One such gallery is said to have been carried in 1776 to the distance of 360 feet; but of the details of these early explorations we have only very imperfect accounts. In 1820 Count Sternberg had himself caused a shaft 27 feet deep to be sunk in the midst of the Zwergeloch; and Heinrich Cotta had in 1826 put down two pits at the summit and base of the hill respectively, with a view to more fully determining the materials of which it is composed.

Count Sternberg's experimental works at the Kammerbühl consisted of a shaft on the south-west side of the hill carried down to the depth of 60 feet, and a number of galleries which were driven both from the bottom of the shaft and from the surface into the very heart of the hill. These old workings are now nearly filled with water, but the entrance to them is ornamented by a stone archway bearing the following inscription: "Den Naturfreunden gewidme vom Grafen Caspar Sternberg, 1837." The result of these work was to fully establish the presence of a central mass of basalt in the midst of the hill; the presence of which had been affirmed by "the Vulcanists," and denied by "the Neptunians." From the results of these workings we are enabled to give the accompanying section of the Kammerbühl, Fig. 3.

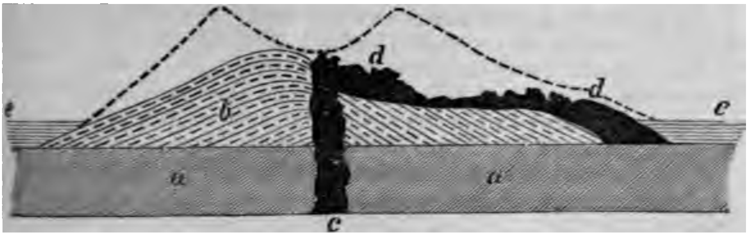

Fig. 3.—Section of the Kammerbühl in Bohemia.

a, a. Metamorphic rocks.
b. Basaltic scoriæ.
c. Solid mass of basalt rising through the centre of the volcanic pile.
d, d. Lava stream composed of the same rock.
e, e. Alluvial matter surrounding the old volcano.
N.B.—The dotted lines indicate the probable former outline of the volcano.

English readers will doubtless call to mind that a similar experimental test was at an earlier date suggested by Hutton, in the case of the veins of the Salisbury Crags, and was carried out by his friend Sir James Hall.

We have been led to dwell at some length on this story of the Kammerbühl, because that object forms such an interesting and instructive link between the undoubtedly extinct volcanos and the so-called masses of "trap-rock." All through Northern Bohemia, as well as in the districts of Silesia lying to the east, and in those of Bavaria to the west, isolated masses of basalt, like that occupying the centre of the Kammerbühl, occur by hundreds; and the same is found to be the case in the districts of Central Germany lying between the Thuringerwald and Hartz Mountains on the east, and the Rhine on the west. In many cases, as near Eisenach and Fulda, such masses of basalt are shown by quarrying operations to be truly intrusive, and are seen to have given off veins into and metamorphosed the surrounding rocks. Very interesting details concerning the physical and petrological features of some of these old volcanic ducts have recently been given by Prof. Möhl of Cassel.

If districts, like those of the Auvergne or the Eifel, which exhibit great numbers of small volcanic cones, were subjected to such an amount of denudation as would remove the sheets of lava and the piles of scoriæ, no trace would be left of the sporadic outbursts of igneous forces, but a number of isolated masses of basalt or other igneous rock, rising through the surrounding strata. Can we then doubt that areas (such as those we have above referred to) which present precisely these appearances were once surmounted by scattered cinder cones ("puys") and lava currents ("chières"), and that these have been removed by denuding forces?

Of the larger volcanic mountains much more striking and conspicuous evidences will of course remain, in hills of intrusive rock, and more or less isolated plateaux composed of lavas and alternating volcanic agglomerates. Such may be witnessed in the three great ruined volcanos of the Auvergne, those of the Siebengebirge, the Westerwald, the Habichtswald, the Vogelsberg, the Rhongebirge, in Central Germany, the Duppauer Gebirge and the Leitmeritzer Gebirge in Bohemia, and many similar masses in Hungary. Nowhere, however, can the phenomena presented by such a great ruined volcano be better studied than in the interesting Euganean Hills in the North of Italy. Here, as Prof. Suess of Vienna has so well shown, denudation has operated to such an extent as to bring to light in the most admirable manner the general ground-plan of a volcano,—which he believes must have rivalled Etna in dimensions,—besides revealing innumerable instructive sections of its mass. From the centre of this ruined volcanic pile numerous dyke-like masses of vast proportions, and composed of different varieties of lava, are found penetrating the beds of tuff in all directions; these of course marking the several fissures which were formed on the flanks of the cone, and injected with lavas during its gradual growth.

By examining the relation of such masses of rock, whether of larger or smaller dimensions, the volcanic origin of which has now been placed beyond dispute, to the various sedimentary and fossiliferous formation, they can be proved to have been erupted during every one of the epochs into which geologists have divided the vast periods concerning which the "records of the rocks" afford us any information.

The task of determining the geological age of a series of volcanic rocks is often, however, one of considerable difficulty; and hence most geologists, in constructing their maps, are content with merely indicating the extent and character of the igneous masses, and of perhaps showing also their relations to the sedimentary deposits, without attempting to classify them, as they do the latter, according to the period of their formation.

But it is evident that, as we make progress in our study of the earth's crust, we must not be satisfied until we can refer each of the outbursts of volcanic forces to its proper place in the geological history of the district; nor until our maps indicate the *ages* of the igneous as well as those of the aqueous deposits. Then only indeed will they truly deserve the title of "geological maps," and we shall be in a position to reason from them concerning the sequence and relations of geological events—whether of the slower movements which affected the earth's crust, during the quiet accumulation of sediments, or of the more sudden and violent ones, that heralded, accompanied and followed the paroxysmal outbursts of the volcanic forces.

It will be useful then to inquire what are the means which the geologist possesses for determining the date of formation of different *igneous deposits.*

ose masses composed of scoriæ, tuffs, or ashes, which are ted during a volcanic outburst, are usually among the first oducts that yield to the wasting effects of denudation ; and organic remains, which are not unfrequently overwhelmed veloped in such materials, have in too many instances totally red. Occasionally, however, in consequence of their being up by masses of hard lava, or through being buried under ent sedimentary deposits, such fossiliferous volcanic agglo-, tuffs or ashes have been preserved, and furnish us with palæontological evidence of the period of the outbursts by hey were formed. Sometimes, indeed, owing to the process ification having gone on in the mass, the fossils contained igneous rocks are unrivalled for their beauty and admirable ration. As examples of such we may mention the terrestrial insects, shells and bones of Saros Patak, and other localities ngary, of Lipari, Somma and Ardtun ; the lacustrine shells, , fishes and mammals of Bohemia and the Auvergne ; and the plants, shells and fishes of Ischia and the Vicentine.

in too many cases, unfortunately, this direct palæontological ice of the date of a volcanic outburst is altogether wanting, and ologist is compelled to fall back upon less direct, though not sarily less conclusive, evidence. Foremost among such we mention the mode of association of the igneous rocks in question sedimentary deposits, the age of which is known.

re, however, we must point out that the *mere association* of us masses with a particular geological formation affords no whatever of their contemporaneity; and geologists have nfrequently been led into the most serious error through too ly assuming such to be the case. Thus in the West of Scotland asalts are so constantly associated with the Jurassic rocks, that y one was at first led astray concerning their age by this acci-al connexion; and it was only by the discovery of Miocene ts in their tuffs, and of their superposition to the highest aceous rocks, that the fallacy of the inference as to their Jurassic was made apparent. So also in Bohemia, as I had an oppor-ty of observing under the guidance of Prof. Fritsch of Prague, y isolated masses of basalt are found in the midst of outliers of k ; in this case, also, the association is purely accidental, the lts being unquestionably of late Tertiary age, while the masses halk around them appear to owe their preservation to a certain unt of induration produced in them by the igneous intrusion.

hus it becomes clear that, in reasoning on the age of igneous s, we must convince ourselves not only of the *fact*, but of the *re* of their association with the sedimentary rocks.

here igneous masses are found clearly overlying sedimentary sits, or where they penetrate between the aqueous beds in sheets, lucing alteration both in the strata above and below them ; or re they traverse the sedimentary formations in dykes, or enclose ions of the latter, whether as entangled fragments caught up va, or as ejected masses enclosed in the agglomerates ; or again where alteration has clearly been produced in the sedimentary rocks in the vicinity of the igneous; then in all these cases the latter are undoubtedly of *more recent* date than the former.

But where, on the other hand, the fossiliferous sedimentary rocks overlie the whole of the igneous rocks occupying the depressions produced in them by denudation, or where the former contain pebbles derived from the latter, then we may confidently pronounce the igneous masses to be the older of the two.

It is evident that if the relations of a series of igneous rocks be thus studied, we may often, by excluding certain geological periods as certainly more recent, and others as undoubtedly more ancient, arrive at an approximate date for the outbursts by which they were formed.

If, however, the igneous masses, whether lava-streams or tuffs, are seen to be interbedded with a series of fossiliferous sediments, the former having clearly produced alteration in the *underlying* strata, while those superposed to them are unaffected,—then we are perfectly safe in inferring that both the igneous and aqueous rocks were produced during the *same* geological period.

There are undoubtedly cases in which we are unable to apply either of the methods which we have noticed above, whether direct or inferential, to the determination of the age of a series of volcanic deposits. In such cases, however, the analogies or relations of such igneous masses with others of which the date can be determined, may be sufficient to warrant us in assuming with a high degree of probability that they were formed during the same period.

Some geologists have maintained the opinion that the chemical and mineralogical features of volcanic rocks afford in themselves sufficient evidence of the date of their formation. But we cannot admit, in the present condition of our knowledge, such to be the case; there are certainly rocks of the most widely different age, but which, having been subjected to similar processes of alteration, are now quite undistinguishable in character by any test which we are able to apply. We shall not, however, be misunderstood as upholding *the converse* of this position, and asserting that all igneous rocks of former geological periods are identical in character and composition with those being formed at the present day. On the contrary, we are driven to the conclusion that while many facts seem to point to the identity of character of ancient and modern igneous rocks, there are not a few others which may be cited as tending to prove that, alike in their ultimate composition and their component minerals, the igneous rocks exhibit remarkable peculiarities in their distribution, both in space and time.

As the result of the studies carried on by geologists concerning the age and relations of the igneous rocks in different districts, no fact comes out more strikingly than that of the constant shifting of the centres of volcanic action. We find unmistakable evidence of the alternation in the same area of epochs characterized by great volcanic outbursts, with others in which the gradual deposition of sediments was clearly not interfered with by any such cause.

Thus, in those portions of Northern Europe which have been best studied by geologists, there is ample proof that the three periods of the Lower Silurian, of the Upper Palæozoic (extending from the Devonian to the Permian), and of the Miocene, were all marked by the most violent outbursts of volcanic forces; while in the intermediate periods few, if any, traces of such action can be discovered. But when we pass to other areas, we find the most violent outbursts taking place in what are with us periods of quiescence, and *vice versâ*. Nothing is more certain than that, during the middle portion of the Tertiary period, the districts of Western Europe must have been the scene of volcanic violence, on a scale perhaps far surpassing what is now seen in South America or the Indian Archipelago; and that ever since that period a gradual decline of the volcanic forces has been taking place in our area.

Seeing, then, that it is absolutely certain that in a district long unmarked by volcanic disturbances these powerful subterranean agencies may make their appearance, gradually attain their climax, and then die away, the following questions present themselves as being of the greatest interest to the geologist: What are the circumstances and attendant phenomena which mark the first appearance of volcanic activity in an area hitherto quiescent? What are the several stages through which the manifestation of igneous forces successively passes in reaching its climax? And what are the symptoms that mark their gradual decline and extinction?

With these there presents itself another problem, namely, that of the relation of the violent actions attending volcanic outbursts to the perhaps equally powerful, but more slow and extended, movements which take place in adjacent areas not exhibiting any manifestations of the volcanic phenomena.

On all these questions we think important light is thrown by the study of the volcanic rocks of Central and Southern Europe, and of their relations to the great central rock masses of the Alpine system; and to these we shall proceed to direct attention in subsequent chapters.

(*To be continued in our next Number.*)

III.—SKETCH OF THE GEOLOGY OF ICE SOUND AND BELL SOUND, SPITZBERGEN.

By Professor A. E. NORDENSKIÖLD, of Stockholm.

PART II.

(*Continued from the January Number, page* 23.)

THE Fossil Plants from Bear Island have been described by Prof. Oswald Heer; there are 18 species (see Quart. Journn. Geol. Soc. Lond. 1872, vol. xxviii. pp. 161–173. pl. iv.), namely:—

1. *Calamites radiatus*, Brgn.
2. *Cardiopteris frondosa*, Goepp. sp.
3. ———— *polymorpha*, Goepp. sp.
4. *Palæopteris Roemeriana*, Goepp. sp.
5. *Sphenopteris Schimperi*, Goepp.
6. *Lepidodendron Veltheimianum*, Sternb.
7. ———— *commutatum*, Schimp.
8. ———— *Carnegyianum*, Heer.
9. ———— *Wijkianum*, Heer.
10. *Lepidophyllum Roemeri, Heer.*
11. *Knorria imbricata*, Sternb.
12. ———— *acicularis*, Goepp.
13. *Cyclostigma Kiltorkense*, Haught.
14. ———— *minutum*, Haught.
15. *Halonia tuberculosa*, Brgn. ?
16. *Stigmaria ficoides*, Sternb.
17. *Cardiocarpum punctatum*, Goepp. et Berg.
18. *Cardiocarpum ursinum*, Heer.

Some of these species perhaps may be found in Ice and Bell Sounds. Hitherto there have been found in these places only—

In Ice Sound (within Gip's Hook):[1]

1. *Calamites radiatus*, Brgn.
2. *Lepidodendron Veltheimianum*, Sternb.
3. *Stigmaria ficoides*, Sternb. Beautiful specimens, with rootlets attached.
4. *Cyclostigma Nathorsti*, Heer.
5. Fruit of a *Rhizocarpum*.

In Bell Sound (north shore, immediately outside Axel's Islands):

1. *Calamites* (probably *radiatus*, Brgn.).
2. *Knorria imbricata*, Sternb.

B. *Mountain Limestone Proper.*—Both the Hecla Hook and Liefde Bay strata, and the strata included in the foregoing division, consist of fresh-water formations, devoid of any trace of marine fossils; which proves that Spitzbergen, during the immense period of time in which these strata were deposited, formed a considerable continent. Later, however, these circumstances were altered, inasmuch as that part of the globe was again covered by sea, from which, with only an inconsiderable, perhaps local, break (the strata of the Coal-formation in Bell Sound), during a long sequence of geological periods, strata of great extent, containing marine fossils, were deposited. The oldest and most extensive of these strata belong to the Mountain Limestone formation, which in this part of the polar regions is specially developed and rich in fossils.

The most remarkable localities are Bear Island, Mount Misery, and the neighbourhood of Tobieson's hut, on the north side of the island. I have given an account of the stratification in the above-quoted treatise of Heer. The Mountain Limestone fossils from this place were discovered first by Keilhau, and a few species are described by von Buch.[2]

South Cape.—Hence Keilhau brought home some few fossils, which are preserved in the Museum at Christiania. The fossils described by Toula, which were collected by Payer, are also from this locality.

Horn Sound.—According to Professor Höfer, extensive Mountain Limestone strata occur here in the region of Burger Harbour, and on the western side of Marien-Spitz.[3]

Bell Sound.—Some Mountain Limestone fossils from this locality were collected by Robert during the French Expedition in the Recherche, and are described by von Koningk,[4] and figured in the large atlas of the voyage of the French Expedition. Lamont also collected Mountain Limestone fossils in this fiord. These are described by Salter in the Appendix to Lamont's account of his voyage.[5] During the Swedish polar expeditions I have repeatedly visited this fiord, and collected a great many Mountain Limestone fossils, part from Axel's islands, and part from the land right opposite, lying on the north side of the fiord.

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[1] Heer, Beiträge zur Steinkohlen Flora der artischen Zone, Vet. Akad. Handl. B. 12, No. 13, 1874.

[2] Abh. der Akad. d. Wissensch. zu Berlin, 1846, s. 65.

[3] Sitzungs Ber. der K. Akad. d. Wissensch. in Wien, Nov. 1873; June, 1874.

[4] Bulletin de l'Acad. Roy. de Belgique, tom. xiii. (No. 6), and tom. xvi. (No. 21).

[5] Season with the Sea-horses, by J. Lamont, London, 1861.

Ice Sound.—Partly round the *mouth of the Sound* on the island lying in the neighbourhood of Safe Haven to the north-east, and in the high range between Green Harbour and the sea (at that place first discovered by Lovén in 1837), partly in the *inner part of the Sound* at Skansberg and Gip's Hook, on both sides of Klaas Billen Bay, at Cape Wœrn, between Ekman and Dickson Bays, and on Cape Wijk, lying opposite.

King's Bay.—Mountain Limestone fossils were brought home by Blomstrand, during the expedition of 1861, from the land on the south side of the mouth of the fiord above the Coal Harbour.

Hinloopen Straight.—South of Lomme Bay and Wahlenberg Bay. Lovén's and Angelin's mountains, etc., and the lofty and magnificent mountains bordering on the southern part of Hinloopen, are formed principally of strata of limestone and flint, which belong to the Mountain Limestone formation, and are extraordinarily rich in fossils.

The Southern Part of Stansforeland, near Deevie Bay.—Here, too, Lamont collected Mountain Limestone fossils, which, together with fossils from Bell Sound, are described in the work quoted above.

At several places the strata are exposed in extensive and instructive profiles, which show the succession to be the following:

1. (Lowermost) *Russian Island Dolomite.*—A peculiar, grey dolomite, yellow after weathering, which contains no fossils, and which in Klaas Billen Bay lies immediately above the sandstone, with Calamites, etc., described in the foregoing division. This dolomite (from an island at Shoal Point), according to an analysis by G. Lindström,[1] contains:

Carbonate of lime	54·07
„ of magnesia	44·77
„ of protoxide of iron	0·32
Chlorine	trace
Remainder, incombustible and insoluble in acids	0·24
	99·40

Like the dolomite from the Hecla Hook formation, from which, however, it can easily be distinguished by its outward appearance, the composition of this dolomite corresponds accurately to the formula

$$CaO\ CO_2 + MgO\ CO_2.$$

The Russian Island dolomite is remarkable for a very peculiar coral-like structure. It shows scarcely any sign of stratification, but is interstratified, particularly on the Russian Islands in Murchison Bay, with regular strata of limited extent, partly of flint, which is also devoid of fossils, but resembles the fossil-bearing flint on Axel's Islands in Bell Sound, partly of a mixture of flint and chalk, in which the flint often forms cylinders 3 to 8 millimetres thick, bent and folded in a multitude of ways, which in form completely resemble coral stems, but are believed to be altogether destitute of interior structure.

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[1] Oefvers. af Vet.-Akad. Förh. 1867, page 672.

2. *Red and White Sandstone.*—Pretty loose and containing indeterminable dark spots, probably the remains of sea-plants. Occurs only at the foot of Cape Fanshawe, where it overlies the Russian Island dolomite and under the following division. Formerly I identified this sandstone, which besides is thought to occur quite locally, with the Bear Island coal-bearing sandstone.

3. *Cyathophyllum Limestone.* — The above-mentioned sandstone stratum is completely absent in Ice Sound. Instead, the Russian Island dolomite is overlain by, or more correctly passes into, a dolomite rich in coral stems. The same stratum in Bell Sound immediately succeeds the lower Mountain Limestone ("Ursa stage"). This stratum also contains corals, and in Bell Sound a *Euomphalus* and remnants and fragments of tests of Crinoids, in Lomme Bay near Cape Fanshawe *Brachiopods*, which, however, are distinguished from the Brachiopods in the next following divisions by their size being smaller than ordinary.

4. *Spirifer Limestone and Gypsum.*—A somewhat loose grey limestone (or dolomite?), particularly rich in remains of *Spirifer* and Brachiopods belonging to allied genera (the genus *Productus* is here less numerously represented); overlies the strata belonging to the preceding division, on the north shore of Bell Sound, right opposite Axel's Islands. In Klaas Billen Bay, again, the *Cyathophyllum* stratum is covered by a stratum of gypsum, generally grey in colour, and infused with nodules of white alabaster, which at first is soft, but hardens when kept dry for some time. Anhydrite is also found in some places in abundance along with the gypsum. On Bear Island and at Hinloopen (where the strata of gypsum are absent), this division is thought to correspond, in the former place, to a stratum of sandstone,[1] with *Spirifer Keilhavi*, Buch, and in the last-mentioned place to a sandstone mixed with limestone, and infused with green specks, and which is particularly rich in large well-preserved Brachiopods, *Productus* included. It is probable that there is no true palæontological separation between this division and the following.

5. *Productus Limestone and Flint.*—In Ice and Bell Sounds, as well as in Hinloopen, the Spirifer Limestone and gypsum are covered by a stratum of impure limestone rich in silica, or by a black flint, extraordinarily rich in fossils, specially in *Producti* of large size and with large shells. Within this division the flint strata of silica are scarcely ever of the nature of sandstones, but form beds, several hundred feet thick, consisting of a nearly pure flint, and I think it highly probable that the formation of these immense flint beds stands in connexion with the eruptions whence originated the massive layers of plutonic rocks, which meet us everywhere on Spitzbergen, and which in many places form the very boundary between the Mountain Limestone and the overlying strata belonging to later formations. The profiles below exemplify the mode of occurrence of the strata belonging to this division in Bell Sound and Ice Sound.

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[1] According to von Buch, Keilhau states that Mount Misery consists entirely of sandstone (compare von Buch, Berlin Akad. Ber. 1846, p. 145). This statement, however, is incorrect.

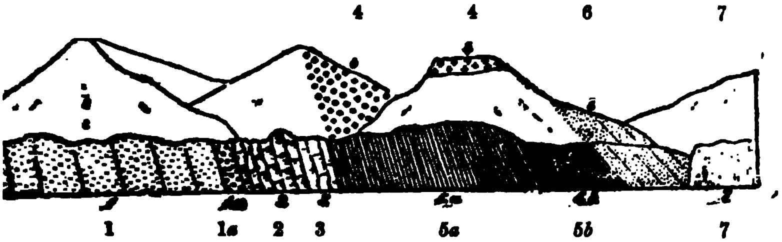

Fig. 4.—Profile of the North Shore of Van Mijen Bay, East of Frithiof's Glacier.

1. A white, hard sandstone, mostly devoid of organic remains. In a neighbouring island, however, are found imbedded in the sandstone impressions of *Calamites*, etc. and the sandstone therefore belongs to the same division as the Coal-bearing stratum on Bear Island. 1*a*, an inconsiderable layer of conglomerate.

2. *Cyathophyllum Limestone.*—A hard, grey, impure limestone or dolomite containing corals (*Cyathophyllum*), a *Euomphalus*, and portions of bodies and stems of Crinoids.

3. *Spirifer Limestone*, loose, grey, consisting almost exclusively of remains of Brachiopods.

4. A vein of diabase of great extent.

5. Flint, rich in impressions and remains of Brachiopods, especially of *Productus*. Similar, though less extensive flint beds, but without fossils, lie between the *Cyathophyllum* Limestone (etage 2), but crop out first east of these limestone strata in such abundance that they form the principal mass of the mountain. It is possible in this mighty succession of strata to distinguish two divisions.

5*a*. A grey (but becoming yellowish-brown through weathering), very close and compact sandstone containing lime, which, when freshly broken, has a homogeneous appearance, but when exposed for a considerable time to the action of the atmosphere, has a rough and irregular surface.

5*b*. A black flint, weathering to a limited extent when exposed to the air. These strata are quite identical in respect of the organic remains they contain. The former take up nearly the whole of Axel's Islands; the latter a small ridge on the east side of the island. On the southern island this flint stratum is covered by a pretty loose marl-schist with fossils of various kinds.

6. Sandstone with traces of vegetable impressions, probably belonging to the same period of time as the stratum in Robert's Valley (IV., C.)

7. Frithiof's Glacier.—On the low land, which is now taken up by the glacier, were observed in 1858 both black schists and a grey sandstone, which in all probability also belonged to the same period of time as the stratum in Robert's Valley, and in the grave-mound now covered by ice, layers of a black schist rich in pyrites, which probably belongs to the Jurassic formation.

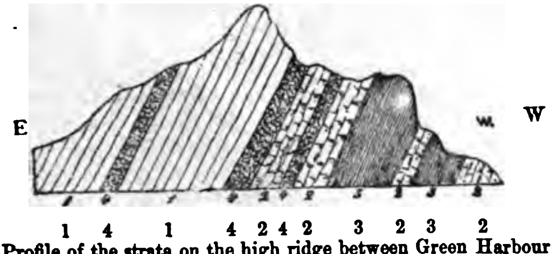

Fig. 5.—Profile of the strata on the high ridge between Green Harbour and the sea, by von Drasche.

1. Grey limestone, containing silica, with a few fossils (*Spirifer* and *Productus*). 2. Grey sandstone, yellow after weathering, with an immense number of fossils (Bryozoa, Corals, *Spirifer*, *Productus*, etc.). 3. Flints, containing no fossils. 4. Layer of diabase, with pretty large felspar crystals.

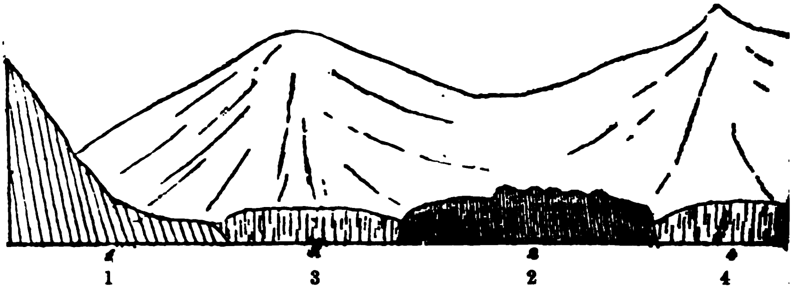

Fig. 6.—**Profile of Strata at Safe Haven.**

1. The foot of the Alkhorn, consisting of Hecla Hook strata. 2. Section of peninsula on the east side of Safe Haven, formed of vertical layers of limestone, containing silica and flint, very rich in fossils, *Productus*, *Spirifer*, etc. (etage 5). 3 and 4. Glaciers with steep inclination: 3 in the bottom of Safe Haven, 4 east of the peninsula.

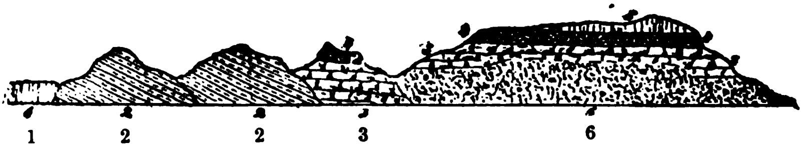

Fig. 7.—Profile of Strata on the east side of Ekman Bay.

1. Glacier. 2. Red Liefde Bay schists. 3. Dolomite, Spirifer limestone and flint. 4. Diabase. 5. Snow-field (mer de glace). 6. Rock debris.

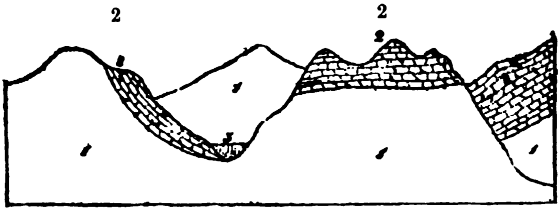

Fig. 8.—Profile of strata at the bottom of Klaas Billen Bay (according to von Drasche).

1. Liefde Bay strata (formerly referred to the upper part of the Hecla Hook formation). 2. Mountain Limestone. 3. Glacier.

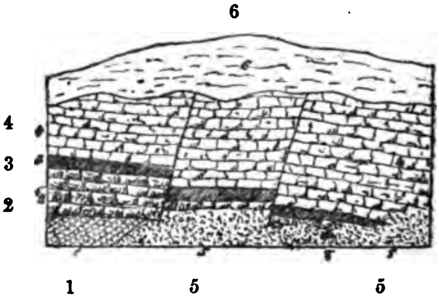

Fig. 9.—Profile of Gip's-hook (according to Nathorst).

1. (Lowermost) Sandstone and conglomerate of very sharp-cornered pieces of uartz, above which—
Clay-slate containing coal, mixed with sand, with *Lepidodendron*, *Stigmaria*, and *alamites*, etc., and uppermost,
Red sandstone and conglomerate, containing fragments of Liefde Bay strata. The nglomerate is much weathered and broken down, in the bottom red, then green, then ellow. These strata probably belong to the lower Mountain Limestone (Ursa-stage).
2. Lowermost Russian Island dolomite, above which *Cyathophyllum* strata.
3. Stratum of gypsum 150 to 200 feet thick.
4. Mountain Limestone with *Spirifer* and *Productus*. In these strata occur flint ds of great thickness.
5. Places covered by debris.
6. Snow-fields which, on the highest part of the mountain, are not melted during mmer.

Of the fossils found in these strata, our distinguished palæontolo-ist Dr. G. Lindström, of Wisby, has given the following sketch, but ith the reservation that it is only a provisional statement. An xhaustive dissertation on them will be communicated to the cademy of Science at a future period. The material for examina-on which Dr. Lindström had at his disposal forms, however, only e lesser part of the collections brought home by the Swedish xpeditions. The principal part has been handed over upwards of n years ago to the Superintendent of the Palæontological Division f the Riks Museum.

"The number of Mountain Limestone fossils collected during the xpedition of 1868 and since amounts to 63, besides undetermined ragments of several others. Of this number

2	species belong to	*Crustacea*
2	" "	*Gasteropoda*
11	" "	*Lamellibranchia*
34	" "	*Brachiopoda*
7	" "	*Polyzoa*
2	" "	*Crinoidea*
4	" "	*Anthozoa*
1	" "	*Spongia.*
63[1]		

The great preponderance in the number of species, their well-preserved condition and the greater certainty arising therefrom in determining them, serve to make the *Brachiopoda* better fitted than any other group for a comparison of the Mountain Limestone fauna of Spitzbergen with that of other lands. What first strikes one with surprise in doing so is that this fauna contains several species which have been hitherto known only as Permian. There can no longer be the slightest doubt that these, which have been considered *exclusively* Permian, and consequently in a high degree characteristic of that formation, rest in Spitzbergen and Bear Island in beds which contain a larger number of species exclusively characteristic of the Mountain Limestone. Such '*Permian*' species are *amarophoria Humbletonensis*, Howse; *Productus cancrini*, Verneuil; *roductus Leplayi*, Vern.; *Productus horridus*, Sow.; *Strophalosia amellosa*, Geinitz.

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[1] To this number might be added several, as *Spirifer Keilhaui*, Buch, etc., if I ere not doubtful of their identity, as they are absent in the collections formed by ordenskiöld, and I have not otherwise had opportunity to see them.—G. Lindström.

A couple of others, *Athyris Roissyi*, Léveillé, and *Camarophoria crumena*, Mart., were also considered to occur only in Permian strata until Davidson by his accurate researches showed, in his monographs on the Permian and Carboniferous Brachiopoda of England, that they were common to both formations. He considers (according to Ramsay, Anniv. Addr. of the Pres. Geol. Soc. of London, 1863, page 22) that the half of the Permian Brachiopoda were surviving Mountain Limestone species. We must suppose, for example, that *Productus cancrini* also occurs in the Carboniferous formation in Russia and England, and thus is one of the common species; but there still remains, besides *Strophalosia* and *Camarophoria*, a type so distinct as *Productus horridus*, which occurs in Spitzbergen as two different races or varieties, of which one attains a giant-like size, viz. 86 millimètres in height and 67 mm. in breadth, while the largest Permian specimens are only 43 mm. high and 42 mm. broad. As the preponderating number of fossils are such as characterize the Mountain Limestone of the Carboniferous formation, we must suppose that types which in the rest of Europe made their first appearance after the formation of the great Coal-measures here lived contemporaneously with species which were anterior to the deposition of these beds in other countries. We may accordingly suppose that the Permian species after the lapse of a lengthened period migrated to the rest from another sea, in which new circumstances had arisen.

What besides gives the Mountain Limestone fauna of Spitzbergen, so to speak, so Permian a character—granting that it is only negatively—is the complete absence of any representative of the genus *Orthis*, which appeared during the Coal Period, and numbered fifteen species, extremely rich in individuals and widely spread, while during the Permian age there was not a single one to be seen.

The Permian is not the only formation with which the Mountain Limestone on Spitzbergen has species in common. *Rhynchonella pleurodon*, Sowerby, increases the number of the species, which, like *Strophomena rhomboidalis* and various Polyzoa and Corals, survived from the earlier Silurian age to the Carboniferous formation. Among the numerous varieties of the last-named Brachiopod is that one Davidson delineated in his monograph on the Mountain Limestone Brachiopoda of England, plate xxiii. fig. 12, *in all* respects completely corresponding with that variety of the Silurian *Rhynchonella Wilsoni*, Sowerby, which he delineated in his Silurian monograph, plate xxiii. fig. 10.

If we accept a number of not less than twenty varieties of species of Brachiopoda, which are distributed over nearly all the countries where the Mountain Limestone is found, there remain some which closely connect the Mountain Limestone of Spitzbergen with that of Russia. These are *Spirifer incrassatus*, *Spirifer bisulcatus*, var. *Sarana*, *Terebratula fusiformis*, *Productus Humboldti*, *Chonetes variolaris*.

The species most characteristic of the Mountain Limestone of Spitzbergen are *Productus cancrini*, *Prod. Weyprechti*, and *Prod. horridus*, which occur in great abundance at most of the localities.

The Brachiopoda previously found on Spitzbergen were only *Productus Weyprechti*, *Chonetes perforata*, *Chonetes scutulum*.

Among the other fossils the preponderating number belongs to the Carboniferous formation, as *Euomphalus catillus*, *Monticulipora tumida*, *Chætetes radians*, *Cyathophyllum ibicinum*, and *Syringoporæ*.

The final result of these preliminary examinations is that the strata from which the fossils are derived truly belong to a division of the Mountain Limestone of the Carboniferous formation, but possess a peculiar character from the intermixture of species occurring in other countries only in the Permian formation. In consequence of the occurrence of these Permian types, the supposition lies ready to hand that the Mountain Limestone of Spitzbergen is a later link, if not corresponding, at least analogous to the Upper Mountain Limestone of Scotland, which is separated from the Lower Mountain Limestone by a series of Coal-beds.

C. *The Carboniferous formation proper.*—Strata belonging to this remarkable age have been found hitherto only to an inconsiderable extent on Spitzbergen, namely, in Robert's Valley, on the eastern side of the great bottom glacier in Recherche Bay. A river, considerable for Spitzbergen, falls into the sea here. One of its banks is formed of the high icebergs of the glacier very uneven and much broken; the other of vertical strata of sandstone and slate, which in many places dip precipitously with a shelf 10ft. to 20ft. high next the river. The slates alternate many times with the sandstone or quartzite, and when wet are coal-black. Coal, however, does not occur here, but abundance of vegetable impressions, especially in a stratum of slate near the mouth of the river. A complete description of these impressions by Professor Oswald Heer will be published in the Transactions of the Academy of Science (Stockholm). In a preliminary statement printed in the Öfversigt[1] this distinguished inquirer says: "Though most of the vegetable remains are so fragmentary as not to admit of accurate determination, it is fortunately the case that others are so complete that they will certainly denote the age of the formation. The most common are small ferns, of which the greatest number belong to the group *Trichomanides*, of the genus *Sphenopteris*. On the contrary, there are none of the larger ferns belonging to the genera *Pecopteris* and *Neuropteris*, elsewhere common in the Carboniferous formation.

"The ribbon-like leaves of *Cordaites* (*C. borassifolia* and *C. primordialis*) and remains of *Lepidodendron* are also common. Of the latter have been found several pieces of bark belonging to tree stems of considerable age, and a couple of very beautiful cones; younger branches are however most common. The species belongs to the same group as *Lepidodendron Sternbergii*, Lindl. Of *Sphenophyllum* and *Asterophyllites* there occur at least scattered leaves. A characteristic fruit, with point deeply cleft in two, allied to *Rhabdocarpus clavatus*, Sternb., is also not uncommon. Of *Stigmaria* there occurs a type with wavy grooved stem and large seams."

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[1] Oswald Heer. "Anmärkningar öfver de af Svenska polarexpeditionen 1872-1873 upptäckta fossila växter," Öfvers. af K. Vet.-Akad, Förh. 1874, No. 1.

These plants show undoubtedly that the black slates at Robert's River belong to the Carboniferous formation, and the species hitherto observed correspond to those of the group of the Coal-measures proper, to the upper division of which they ought perhaps to be referred.

The thickness of these strata I estimate at 1000ft. to 2000ft. The same strata probably extend over Cape Ahlstrand to Van Keulen's Bay, and in that case they form the mass of the high mountains situated at the Cape just named. The place was visited by me immediately before we weighed anchor to return to Tromsö, and unfortunately on that account I could not then extend my examination far beyond the rocks on the shore. Probably the same strata will be found at various other places, for example, on the southern shore of Van Mijen Bay, within Mitter Hook in Bell Sound, and to the same division it is probable that the sandstone and slate, with inconsiderable traces of impressions of plants, which overlie the *Productus*-bearing quartzite and limestone strata, belong. At this place, too, there is no trace of a coal-bed.

In Ice Sound also we find, on the further side of *the Fastness*, a quartzite, resembling the corresponding rock at Robert's Valley; and as it lies between the Mountain Limestone and the Triassic strata, it is highly probable that the upper Coal-formation also occurs here.

V. *Trias.*—Strata belonging to the Alpine Triassic formation are met with in Ice Sound partly at Cape Thordsen, partly south of the entrance to the Sound, a little west of "the Fastness" on Cape Staratschin. At Cape Thordsen the strata are nearly horizontal. Farther inwards on Dickson's Bay and Klaas Billen Bay they rest on strata belonging to the Mountain Limestone formation, and are overlain at the summit of the mountain partly by strata which are probably Jurassic, partly by very thick beds of diabase. The Triassic strata on Spitzbergen consist principally of black clay-slate, interstratified with beds of limestone and coprolite strata, and here and there containing immense perfectly round nodules of limestone. At some of the localities the strata are rich in fossils, partly of invertebrate animals, described by Dr. G. Lindström,[1] partly parts of skeletons of Saurians, on which a short memorandum has been contributed by Mr. Hulke[2] to the Öfversigt of the Academy.

Since the material, which formed the subject of these notices, was described, the coprolite beds occurring here in rich abundance have given rise to an attempt to utilize them for the preparation of manure. With this view Ice Sound was visited in the summer of 1872 by a special Swedish Expedition, in which Dr. P. Öberg took part as geologist. He had thus an opportunity of making a further collection from these interesting strata of a great number of fossils, whereby the material formerly brought home was considerably increased. Dr. Öberg's rich collections have not, however, yet been described.

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[1] G. Lindström. "Om Trias- och Juraförsteningar från Spitzbergen," Vet.-Akad. Handl., B. VI. 1865.

[2] J. W. Hulke. "Memorandum on some Fossil Vertebrate Remains collected by the Swedish Expeditions to Spitzbergen in 1864 and 1868," Bihang till Vet.-Akad. *Handl., Band i. No. 9.*

the Saurian remains, a number of large and beautifully pre- 'ephalopoda excite attention. The succession of strata, at least ırd appearance, is exceedingly uniform. We have—

owermost) A thick stratum of black unfossiliferous clay- This stratum is to be found exposed on the south bank of the ıich intersects Reindeer Valley.

orizontal strata of black slate and seams of limestone con- a great many fossils, which, however belong only to a few among which may be named *Halobia Zitteli*, Lindström, and Cephalopoda strongly pressed together and crushed. These orm the rocks at the outermost point of Cape Thordsen.

stratum of diabase, which at least at Cape Thordsen overlies going stratum, and the surface of which has been split up by to heaps of stone and gravel, probably formed *in situ* of frag- f the diabase stratum.

rata of a dark-grey irregular schist, alternating with seams of ne containing more or less silica, taking up the greater part of ‹s along the shore between a diabase point on the south side Thordsen and the house built by the Ice Sound Company.

ates with limestone seams, containing large round nodules, in re often to be found immense Ammonites, bones of Saurians, ne bivalves, among which *Daonella Lindströmi*, Mojsisovics. east side of Reindeer Valley the limestone is believed to lerate, so that the coprolites here are immediately underlain ey limestone, containing magnesia or dolomite.

thick stratum of black bituminous slate, containing coprolite and alternating with a stratum of pure coprolites, containing ıly up to 23 per cent. of phosphoric acid. Besides coprolites, so occur bones of Saurians and fishes.

rding to analyses by Mr. G. Lindström, the Assistant in the ogical Division of the Riks Museum, these strata contain :

	a	*b*	*c*	*d*
e of lime	54·40	89·84	54·69	22·35
magnesia	2·39	trace	20·56	1·45
protoxide of iron	1·15	·19	4·80	8·93
of lime	·14	trace	·14	·60
	4·01	1·95	·34 (& F̈e)	9·66
tible residue insoluble in acids	32·31	6·20	18·55	45·49
	trace	trace	trace	trace
us matter and moisture	5·60	1·82	——	11·06
ic acid	——	trace	——	·52
copper	——	——	——	trace
	100·	100·	99·08	100·

	e
Lime	42·67
Magnesia	trace
Protoxide of iron	·58
Incombustible residue insoluble in acids	16·01
Chlorine	trace
Fluorine	·86
Bituminous substances and moisture	16·59
Phosphoric acid	23·49
Sulphuric acid	trace
	100·

a. Slate from Etage 2, formed almost exclusively of shells of *Halobia*. *b*. Nodules, containing *Nautilus*, etc., from Etage 5. *c*. Grey limestone from the same Etage, at Saurieberg, underlying the coprolite stratum in Etage 6. *d*. Black bituminous slates, which accompany the coprolite strata at Sauriehook. *e*. Coprolite from Sauriehook.

The matter soluble in acids in *e* corresponds, if we suppose a small part of the lime to be replaced by protoxide of iron, to the formula $2\ \mathrm{Ca\ O\ CO_2} + \mathrm{Mg\ O\ CO_2}$. The average of a large quantity of coprolite brought home in 1872 gave 23·02 per cent. phosphoric acid.

Similar strata, also belonging to the Triassic formation, are to be found at the mouth of Ice Sound, where they lie between the Mountain Limestone and the Jurassic strata, and are strongly dislocated. They take up the rocks along the shore two or four thousand feet west of "the Fastness." The strata consist principally of slates, often infused with coprolite grains and nodules, and alternating with strata of bituminous limestone and thick coprolite beds.

The Triassic fossils on Spitzbergen consist partly of Cephalopoda and bivalves, partly of remains of vertebrate animals, which occur either imbedded in a brownish-black limestone containing coprolites, or in a grey slate, or in the before-mentioned colossal limestone nodules inclosed in the slate. Loose pieces also of bones of Saurians are found among the rock-débris, and are then often of a beautiful turquoise colour on the surface.

Of the vertebrates Mr. Hulke has been able to refer three species to known genera, viz.:

Ichthyosaurus polaris, Hulke. The fragments of bones, consisting of vertebræ and ribs, show that this species was of about the same size as *I. platyodon*. Among the remains of bones collected by the Expedition of 1868 Mr. Hulke remarks of two specimens numbered 46 and 49, that they "have baffled my efforts to decipher their nature." These bones lay in the same limestone nodule as the series of eight vertebræ, etc., first described by Hulke (*I.a*), and are certainly parts of the same skeleton.

Ichthyosaurus Nordenskiöldii, Hulke. To this species are thought to belong most of the smaller vertebræ which we brought home from Ice Sound.

Acrodus Spitzbergensis, Hulke. Mr. Hulke thinks he can with certainty refer a tooth found at Saurie Hook to this genus.

Many other bone fragments it has been impossible as yet to determine with certainty.

Of invertebrates Dr. Lindström enumerates the following species:

Nautilus Nordenskiöldii, Lindström.
Ceratites Malmgrenii, Lindstr.
Ammonites Gaytani, Klipst.
Posidonia, sp.
Halobia Lommelii, Wissm.
——— *Zitteli*, Lindstr.
Monotis, sp.
——— *filigera*, Lindstr.
Pecten, sp.
Lingula, sp.
Encrinus, sp.

The phosphates, abundant in these beds, occur partly as nodules consisting exclusively of coprolite of about 30 mm. diameter, partly in strata which exclusively consist of a highly peculiar aggregate of black round, sharply-defined, equal-sized grains of phosphate of about 1 mm. diameter, cemented by carbonate of lime. The whole resembles a mass of sporting powder compacted together. When the larger coprolite nodules are cut in two, they too are often found to be composed of similar round grains, whence the conclusion may be drawn that the phosphatic strata were formed by the washing down of excrements of Saurians and fish. At two other places the slate beds have intercalated between them strata of grey gypsum of little thickness (at most 2 metres) containing nodules of coprolite. At the same places, especially in the above-mentioned round nodules, there are also found small quantities of rock oil, and the black slates are sometimes so bituminous that they can be used as fuel.

(*To be continued in our next Number.*)

IV.—Cretaceous *Gasteropoda.*

By J. Starkie Gardner, F.G.S.

FOLLOWING up the notes which recently appeared on Cretaceous *Aporrhaïdæ*,[1] I now propose to continue from time to time notes on other Cretaceous Gasteropoda. At present I have selected for illustration "*Scalariform Shells.*" The most recent papers which refer to this subject are witnesses how much revision of the genera and species is needed to which our British Cretaceous representatives of this type have been assigned. I first take the family of *Scalidæ*, and will, as briefly as possible, endeavour to recapitulate what is at present known of this family.

Family Scalidæ, H. and A. Adams, 1857.

(Genera of Mollusca, vol. i. p. 220.)

Bibliography.—Synonyms: *Scalaridæ*, Chenu, Man. Conch. p. 217.
Scalaridæ, Gray, Guide, 1857.

The group of *Scalaria* was separated by H. and A. Adams from the *Turritellidæ*, and is now made to include thirteen recent and fossil genera and several sub-genera. There are still great differences of opinion with regard to the position of this group; the majority of authors retain it in the family of *Turritellidæ*; others regard it as a distinct family, but retain it next the *Turritellidæ*; whilst Adams and Chenu place it away from the *Turritellidæ*, and next to the *Terebridæ*.

Description.—The shell is solid, spiral, and turreted; the whorls convex, sometimes disconnected, usually with numerous transverse ribs; the aperture rounded, with entire margins; peristome generally broadened and recurved, without any canal or notch. The ribs represent the growths of the shells, marking the successive points occupied by the mouth. The shells are usually white, and are remarkable for extreme elegance of form and delicacy of sculpture. The operculum is spiral, horny, of few whorls. The animals are carnivorous, and have been known to feed upon fresh beef; they greatly resemble those of *Turritellidæ*, the principal differences being exhibited in the dentition. All the animals of this group yield a purple dye.

Distribution.—Their vertical range is from low-water to 80 fathoms, their geographical range embraces every sea, but they are more developed in the Indian Ocean, China, and the Philippines. Five are

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[1] See Geol. Mag., 1875, Decade II. Vol. II. pp. 49, 124, 198, 291, 392.

British. Their fossil range is extremely uncertain, as they are only doubtfully represented prior to the Cretaceous period.

Ribbed and turreted shells seem to have made their appearance as far back as the Silurian age, and one species at least has been assigned to the genus *Scalaria*. Dr. Klipstein's collection from the Trias, in the British Museum, embraces many shells which are both turreted and have transverse ribbing; they are variously named *Cerithium*, *Turritella*, and *Chemnitzia*. It has already been suggested by many as extremely probable that the Cretaceous *Scalidæ* are the descendants or representatives of the *Chemnitziæ* of older rocks, a sufficiently probable supposition, and one which would carry their traceable ancestry to a remote period.

The origin of the family, as now defined, cannot with any degree of certainty be traced further back than the Cretaceous era, the doubtful species found in the Jurassic series appearing to be more allied to *Chemnitzia*. The Cretaceous *Scalidæ* have not the strong characteristics presented by the Tertiary and recent forms, seldom possessing a complete peristome, and never the sharp and well-defined ribs so frequently present in the latter. Some Australian forms approach nearer to these fossils in this respect.

Whilst recent and Tertiary *Scalidæ* present a constant facies, and are easily recognizable by their salient ribs and continuous peristome, the study of the Cretaceous and older fossil forms is beset with difficulties on account of the forms met with which are transitional between *Scalidæ* and *Chemnitzia*, and also, though in a less degree, between *Turritella* and *Cerithium*. It is an extremely rare occurrence to find a specimen with the aperture perfect, and it will be seen that only one of the species described has a circular mouth and complete peristome. The borders of the peristome seem to have had a tendency to disunite, and also present a weakening of the part applied to the preceding whorl; sometimes, indeed, every trace of border in this region has disappeared, and the shell therefore loses the principal character which justifies its association with *Scalidæ*, the lips being thin and the mouth oval, resembling *Chemnitzia*. Notwithstanding, however, the differences in form of the mouth, the greater number of these shells bear such a strong general resemblance to the true *Scalidæ* that they cannot but be placed in that family. It is as well here to remark that there is some analogy between fragments of *Scalaria* and *Aporrhaïs* when the last whorl is not present; but the direction of the ribs may be taken as a sort of guide, those of *Scalaria* being nearly always parallel with the axis of enrolment, whilst in *Aporrhaïs* they are for the most part oblique. Of the thirteen genera into which this family has been divided, two only are apparently represented in the Cretaceous rocks of the British area, *Scalaria* and *Funis*. *Scalariæ* proper, have been divided by d'Orbigny into two groups: 1. *Carinati*, with an anterior keel transverse to the ribs; 2. *Pretiosi*, without keel, and with uninterrupted ribs. The former of these divisions is equivalent to Adams's sub-genus *Opalia*.

In 1868 there were in all 45 species known, to which we are now able to add several new forms.

Group 1.—Genus Scalaria, Lamarck, 1801.

Synonym: *Scala*, Klein, 1753.

Lamarck's name *Scalaria* is generally adopted, although that of Klein has undoubted priority. The description of this genus is taken from Adams's work before referred to, p. 220.

"Shell usually pure white, solid, lustrous, turreted, many-whorled; whorls convex, sometimes separated, ornamented with numerous longitudinal ribs; aperture round, peristome continuous, thickened." There are about 100 recent species.

This group is very poorly represented, and the species are of small dimensions in the rocks under consideration.

Scalaria Queenii,[1] J. S. G., Plate III.[2] Figs. 1, 2, 3.

Upper Greensand, Blackdown.

Shell moderately elongated, angle 40°; whorls nine, very inflated and depressed; ribs thirteen, salient, well-defined, obtuse; striæ few, rounded but prominent. Aperture round, peristome thickened and complete; outer lip broad and reflected. This charming little species is the only one which has come under my notice possessing a circular mouth and complete peristome, and therefore approaches more nearly than any other to the recent *Scalariæ*.

Two small and very perfect specimens are in the British Museum, and the last whorl of a larger specimen is in Mr. Meÿer's possession. They are from the Upper Greensand of Blackdown.

Scalaria Meÿeri,[3] J. S. G., Plate III. Fig. 4.

Neocomian.

Shell elongated; whorls inflated, depressed; ribs about ten, thick, prominent and obtuse, continued to umbilicus; striæ few, of differing strength, most numerous on last whorl; outer lip thickened.

The only two specimens I have seen of this species are not sufficiently perfect to admit of a more complete description. They were found by Mr. Meÿer in the Neocomian of East Shalford.

Scalaria compacta, Sby., Dixon's Geology of Sussex, pl. xxvii. fig. 32. p. 349.

White Chalk, Sussex.

A small depressed species thus described in Dixon's Geology of Sussex: "Whorls rather square, close; ribs very numerous, slightly elevated. A very defective specimen is the only one we have seen of this species." This small *Scalaria* evidently belongs to this group. I have not seen the original.

Scalaria Gastyna, d'Orb., Paléontol. Fr. p. 58. pl. 155. figs. 5-7.

Belongs to this group, but has not been found in England. The shell so named in various lists of fossils is a *Rissoina*.

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[1] Named after a friend, to whom I am indebted for much assistance rendered to me whilst collecting.

[2] Plates III. and IV. illustrative of this paper will accompany the second part of the article next month.

[3] Named after C. J. A. Meÿer, Esq., F.G.S., to whom the discovery of this species is due.

Group 2.—SCALARIA, sub-genus *Opalia*, Adams.

This division of the *Scalariæ* comprises by far the larger proportion of species, both in Europe and elsewhere; they are all characterised by the presence of a well-marked basal keel, which is sometimes also visible at the sutures. I commence by describing the best known and most distinct forms from the Gault, and will then notice the points of difference which exist between them and the Greensand species hitherto known under the same names.

(*To be continued in our next Number.*)

V.—IRISH TIDE HEIGHTS AND RAISED BEACHES.

By G. H. KINAHAN, M.R.I.A., etc.

A GOOD deal of attention has been lately bestowed on the Raised Sea-beaches around the British Islands and the evidence afforded by them as to alterations in the level of the land. Some geologists seem to entertain the idea that such beaches were originally accumulated on horizontal lines; and they have drawn the conclusion, that when one portion is found to be higher than another, it necessarily indicates an uneven rise in the surface of the earth. This idea, however, is erroneous; and the object of this paper is to prove, from the data supplied by the Ordnance Survey and the Admiralty Charts,[1] that the littoral deposits at present accumulating around Ireland are being formed at varying levels.

From the Introduction, by Captain J. Cameron, R.E., to the "Abstracts of the Principal Lines of Spirit Levelling in Ireland," we learn that the zero plane of the Ordnance Survey in Ireland is the level of low water of the spring-tide observed at the Poolbeg Lighthouse, in Dublin Bay, on the 8th of April, 1837, which is 20·94 feet below a mark made in the base of the Lighthouse. At first the different lines of levelling were referred to the low water of spring-tides at various convenient places around Ireland; this, however, was found, on further examination, to be so irregular, that subsequently certain sections were established in different places, where series of spirit-level observations were taken, by which these stations were connected with each other, and thus all the means of the different places were referred to one datum level, that just mentioned. The results of these observations are given at page xii. of Captain Cameron's Introduction, and from his table have been constructed Tables No. I. II. III. and IV.

In column i. of these tables are given the heights at each station of mean water above the Ordnance zero plane, and from it we learn that the height of mean water varies but slightly round Ireland, and that the lowest is at Kilbaha Bay, near Loop Head, on the north of the mouth of the Shannon. Column ii. gives the heights of mean water at each station above the lowest, which occurs, as just stated, at Kilbaha. Column iii. gives the mean height of high spring-tides eight of mean water at each station. Column iv. gives eight of high spring-tides at each station as referred to f the lowest mean water, viz. that at Kilbaha; and from we learn that the lowest rise of spring-tides is at n the east coast of the co. Wexford. Column v. gives ight of high spring-tides at each station above the mean gh spring-tides where this is lowest, that is, at Courtown.

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[1] Nearly all the heights hereafter given are taken from the levellings of the Ordnance Survey, a few being added from the Admiralty Charts in those places where the Ordnance Survey had not stations.

TABLE No. I.

	Col. i.	Col. ii.	Col. iii.	Col. iv.	Col. v.	Remarks.
...	8·395	1·817	5·958	7·775	4·504	
...	7·598	1·020	2·251	3·271	0·000	
.. ...	6·753	0·175	6·247	6·422	3·151	
send	6·660	0·082	5·294	5·376	2·165	
.. ...	6·578	0·000	6·621	6·621	3·351	
...	8 725	2·147	6·455	8·602	5·331	Inside Clew Bay
... ...	8·682	2·104	3·552	5·656	2·385	
... ...	8·709	2·131	3·972	6·103	2·832	At the narrow in the North Channel
le ...	8·479	1·901	2·385	4·286	1·015	
dee ...	8·745	2·167	6·301	8·468	5·197	
... ...	8·638	2·060	7·793	9·853	6·582	
Head	8·184	1·606	7·474	9·080	5·809	

TABLE No. II.

e ...	6·753	0·175	6·247	6·422	3·151	Estuary of the Barrow
West...	6·934	0·356	6·667	7·023	3·752	
oss ...	7·667	1·089	7·155	8·244	4·973	

TABLE No. III.

a	6·578	0·000	6·621	6·621	3·351	Estuary of the Shannon
h	7·358	0·780	7·054	7·834	4·563	
s	8·092	1·514	7·535	9·049	5·778	
ick... ...	8·567	1·989	8·935	10·924	7·653	

TABLE No. IV.

a Bay ...	8·899	2·321	7·081	9·402	6·131	Galway Bay
ay	8·480	1·902	7·373	9·275	6·004	
ghmore...	9·047	2·469	6·491	8·960	5·689	Donegal Bay
rana ...	8·369	1·791	6·632	8·423	5·152	Lough Swilly
wkeel ...	9·029	2·451	4·418	6·869	3·598	Lough Foyle

able No. I. the stations given may be considered on the open ept perhaps Old Head (No. 6) in Clew Bay, co. Mayo. If e a mean of column i. in this table, 8·012 is found to be the eight of mean water round Ireland above the Ordnance zero

lumn ii. of this table it is seen that the height of mean water south-west coast between the mouth of the Shannon (Kilbaha, No. 5) and Waterford harbour (Dunmore, station No. 3) is uniform; on the south-eastward part of the east coast it is a foot higher; and on the N.E., N., and N.W. coast from ss, co. Down (station No. 11), opposite the Isle of Man, to ay, co. Mayo (station No. 6), nearly two feet higher. The of mean water on the N.E., N., and N.W. coasts are not so one another as the heights of mean water on the S.W. coast.

ould be mentioned that the Ordnance Survey have adopted a slightly higher the mean water; they however in their calculation included the stations ay (No. 18, Table IV.) and Mullaghmore (No. 20, Table IV.). Both these however, are so situated that the heights of mean water thereat may be by "counter-tides" generated by land in their respective vicinities.

In column iii. it is shown that the height of high spring-tide is very irregular when compared with that of mean water at the respective places; and either column iv. or v. shows the variation in height of the vertically undulating line formed by the margin of the mean high spring-tide. The last two columns, although interesting in themselves, are not both necessary for the subject of this paper; column v., however, gives data that can be easily understood; and as column iv. was necessary for the calculation of the height of mean spring-tide at Courtown, both are given. In column v., as previously mentioned, Courtown (the rise thereat of spring-tide being the least) is taken as zero; from thence proceeding northward the line of mean high spring-tide rises to 4·5 feet at Kingstown harbour, Dublin Bay; to 6 feet at Clogher Head, co. Louth; and to 6·5 feet at Ardglass, co. Down. North of Ardglass it begins to fall gradually to 5 feet at Donaghadee, co. Down; but afterwards more rapidly, being only 3 feet at Glenarm, co. Antrim, and 1 foot at Ballycastle, opposite the Mull of Cantire;[1] while westward of Ballycastle it rises to 2 feet at Portrush.

Between Portrush and the mouth of the Shannon, round the N.W. of Ireland, we can calculate the heights of the following places above the zero at Courtown from the Ordnance Table: Mullaghmore (Station 20, Table IV.), Donegal Bay, 6 feet; Old Head (Station 6, Tab. I.), Clew Bay, 5·5 feet; Cashla (Station 18, Tab. IV.), Galway Bay, 6 feet; but none of them are in the open sea. We therefore take the following open sea places from the Admiralty Charts:[2] at Culduff Bay, N.E. coast of Donegal, the spring-tide rises to 5·5 feet; at Mulroy Bar, on the North coast of Donegal, to 11·75; at Aran Islands, co. Donegal, 11 feet; at Clare Island, at the mouth of Clew Bay, 12·25 feet; at the West coast of Mayo, north of Killary Bay, 12·25 feet; at Bofin, an island six miles off the N.W. point of co. Galway, 9·5 feet; and at Slyne Head, the point north of the mouth of Galway Bay, 13·25 feet. These different rises of the spring-tide will give approximately the following as the heights above the zero at Courtown: Culduff Bay 3 feet; Mulroy Bar, 4·5 feet; Aran, 4·25 feet; Clare Island, 4·75 feet; West coast of Mayo, north of Killary Bay, 4·75 feet; Bofin, 3·5 feet; and Slyne Head, 5·25 feet. These seem to indicate a gradual rise from Portrush, round the N.W. coast, to Slyne Head; the height of the tide off the coast being less, as shown by the difference (1·25 feet) between the height on the West coast of Mayo and that at Bofin, although not more than 12 miles apart.

From Slyne Head to Kilbaha, on the north of the mouth of the Shannon, there is a fall, the line of the latter place being 3 feet high, which it falls to 2 feet at Castletownsend, co. Cork; after ch to the E N.E. it rises, being 3 feet at Dunmore, on the mouth Vaterford Harbour. Farther eastward, at South Bay, north of enore Point, east coast of Wexford, we learn from the Admiralty rts that it is approximately 1 foot; while as we go northward n Greenore Point, it gradually falls to the zero at Courtown.[1]

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[1] The reason for the rise of tide respectively at Courtown and Ballycastle being less than elsewhere is explained by Haughton in his pamphlet "On the Tides and Tidal Currents in the Irish Sea and English Channel."

[2] For an inquiry of the nature of this paper, the Admiralty heights are not very satisfactory, they not being as trustworthy as those given by the Ordnance, their sounding having been referred to beach marks at different harbours. They, however, give a general idea of the varying heights of the spring-tide at the different places mentioned.

n Tables II. and III. are recorded the differences between the rise he tides at the mouths and far up in the estuaries of the Barrow the mouth of the Shannon. From column v., Table II., we n that the difference between the height of high spring-tide at more and New Ross is nearly 2 feet, while from the same mn in Table III. we find that between Kilbaha and Limerick re is an increase of rise of more than 4 feet.

able No. IV. exhibits the tides in some bays and sea-loughs. m it we see that mean water and high water of spring-tides higher in such places than in the adjoining open sea. In Galway the rise of tide seems at first sight exceptional, being lower at way, the head of the bay, than at Cashla Bay, near its mouth. s, however, may possibly be due in part to the Aran Islands ss the mouth of Galway Bay, which generate "counter-tides," thus form a "Head of the Tide" hereabouts (*see Haughton*). e excess of rise of the tide in this bay is more plainly seen from following heights taken from the Admiralty Charts:—

TABLE V.

Galway	Spring-tide rises	15	feet above its own low water.
Cashla Bay	"	16	" "
Greatman Bay ...	"	15·5	" "
Kilkeeran Cove ...	"	15·25	" "
Roundstone Bay ...	"	13·75	" "
Slyne Head	"	13·25	" "
Killeany Bay Aran Islands ...	"	13·66	" "

tions 1 to 6 are along the north shore of Galway Bay, while tion 7 is on the inside or N.E. shore of Illaunmore, the most rth-eastern and largest of the Aran Islands.

In Donegal Bay there are also "counter-tides," for which reason ullaghmore (station 20, Table IV.) was not admitted into Table I. ese probably account for the high tide in this bay compared with e height of the tide on the coast to the west and north, as pre-ously shown by the heights from the Admiralty Charts.

Now since it is the agency of the spring-tide, principally, which ranges the littoral gravels which would constitute Raised Beaches if lifted, it follows from Tables I. II. III. and IV., column v., that if present sea were to retreat, its margin would form a vertically dulating line. This line may be sometimes even more undulating in that now represented, as some parts of the coast are more open storm waves than others; and if this occurred where the line was, reasons given above, already higher than its mean, the upward

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The tide rises and falls much less on the east coast of Wexford than on its th and south-east coast, between Baginbun and Greenore Points; but we cannot e particulars, as on this sheet of the Admiralty Charts there is no tide table.

deviation of the line would be increased. But, on the other hand, storms might pile up the gravels in places where the line of high spring-tides was lower than its mean, and in such places they would make the line less undulating. It appears, therefore, that the fact of a certain raised beach having different elevations in different places does not lead to the conclusion that necessarily the land has been unequally uplifted since the formation of that beach.[1]

VI.—REMARKS ABOUT THE NEW HEBRIDES GROUP, 22nd April to 11th May, 1875.

By HENRY HOSKEN, Navigating Lieutenant of H.M.S. *Pearl.*
Communicated by R. H. SCOTT, F.R.S., F.G.S.

General Appearance.

Most of these islands appear to be of volcanic origin, their centres rising to high-peaked, cone-shaped, mountains, of from 500 to 6000 feet in height. The weather, east and south-east, sides are clothed with thick forests from base to summit; but the north-west and west sides in many of them have but a thin sprinkling of trees, the slopes being covered with a thick, wiry grass.

Appearance of Upheaval.—Nearly every island of the Hebrides and Banks Groups shows signs of an upheaval; on those on which it was most clearly marked may be noted:—

First, Tanna Island.—This island has the appearance of having undergone a gradual upheaval. The tongues of rock, which jut out from the coast-line, are water-worn. Evidently at one time they were awash, but are now from 15 to 30 feet above the present high-water line. Where the coast consists of abrupt cliffs, it shows signs of having been undermined at various levels. The excoriations run horizontally along the whole face of the cliff. There are several caves, and irregular holes in them. Lumps of coral were observed on the terraces on the west coast, a short distance inland.

Second, Erromango Island.—Five clearly-defined ridges or terraces were distinguishable along the south coast, as far as the eye could reach; which formed steps at the points. This side of the island was densely wooded, with bare spots of white limestone rock, here and there, showing out between the trees.

Third, Sandwich Island.—Has numerous low points, and rises in successive terraces to the base of the volcanic mountains in the interior; there are large mushroom-shaped coral rocks high up inland, old coral rock crops up in all directions, even on the highest levels.

Fourth, Deception, Hat, Lopevi, Star Peak, Mota, and Saddle Island.—These islands are similar in their formation, the first terrace being now formed by the comparatively low points, that stretch out from the highland.

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[1] Round the coast of Great Britain, especially in some of the bays and estuaries, the difference between the heights of high spring-tide is much more marked than around the coast of Ireland.

Fifth, Pentecost Island.—On this island the marks are not so clear, when seen from seaward, but on landing they are noticeable; it has also old coral rock at a great elevation.

The absence of barrier reefs round these islands is a remarkable characteristic; is it due to the gradual upheaval?

The islands have generally a short fringe reef surrounding them. If the above theory is correct, these will, in course of time, form another step of the elevation. The black volcanic rock that shows out from the limestone cliffs at various heights seems to uphold this idea, as this rock must form the base upon which the coral has grown.

NOTICES OF MEMOIRS.

The Drifting Power of Tidal Currents versus that of Wind-waves. By G. H. Kinahan, M.R.I.A., etc.

[Abstract of a paper read before the British Association, Bristol, August, 1875, and before the Royal Irish Academy, Dec. 1875.]

It might have been supposed that the exhaustive Report on Waves by J. Scott Russell, F.R.S., etc.,[1] should have decided the relative effectiveness of the tidal currents and wind-waves with regard to their drifting powers. This, however, seems not to be the case, if we may judge from the recent paper on The Chesil Beach, Dorsetshire, read by Professor Prestwich before the Institution of Civil Engineers, Feb. 2nd, 1875, and the discussion which followed.

In the Report above mentioned, Scott Russell divides waves into four orders:—To the first of these or *waves of translation* belongs the great tidal wave, while wind-waves, according to that observer, (with a certain limitation) belong to the second order; this limitation being that those wind-waves in the act of breaking on a beach change into waves of the first order. Indirectly, however, the wind forms a different order of waves; for if water is piled up in a "narrow" by the wind, the waves induced are "waves of translation."

Scott Russell also proves that a wave of the second order has little or no carrying power; consequently wind-waves can have little of this, except when running up the beach, they become waves of translation, and even then their action is limited to quite a narrow line. In a tideless sea, wind-waves breaking on the coast-line form considerable and permanent banks, as in the Mediterranean, where the detritus brought down by the Rhone is piled during storms on the neighbouring shores, forming banks and lagoons. Considerable wind-wave action also will be found in fresh-water lakes and in brackish-water lagoons, if in the latter the cross-tides counteract one another; but as far as my experience goes in the seas round Ireland, the wind-waves do very little permanent work if unaided by the tidal currents. If wind-waves did effect permanent driftage, it ought to be apparent on the coast-lines; the direction of its movement corresponding with that of the prevailing winds resolved along the trend of the coasts. The direction of prevailing winds is always registered by the lean of the trees on a coast-line, Fig. 1; while the course of the driftage is marked by the sand ridges on banks forming the knee-shaped "invers" or mouths of the streams, Fig. 2; the "inver" being shifted laterally in the direction in which the driftage tends. But the lean of the trees and the driftage of the beach are often in opposite directions.

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[1] Report on Waves, Brit. Assoc. Report, vol. xiii. 1844, p. 311.

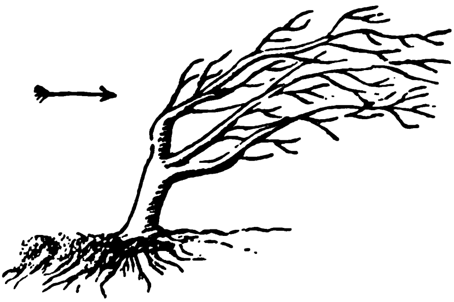

FIG. 1.—Tree bent and growing in the direction of the prevailing wind.

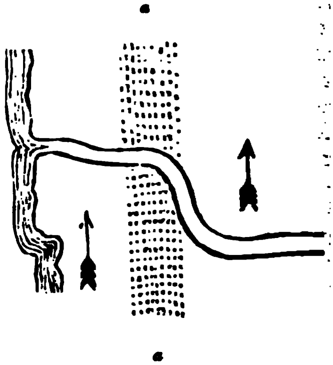

FIG. 2.—Knee-shaped 'invers' at mouth of river, showing the set of the prevailing current.
a. a. Travelling Shingle-beach.

We also find that such a floating body as a ship at anchor always swings with the tide, except in a very excessive gale; and fishermen's nets when they break loose always drift with the tides. So also floating timber drifts with the tide unless it comes so near the shore as to be under the influence of wind-waves, after they have become "waves of translation."

The study of the tidal currents on the coasts of Ireland teaches us that they have little or no driftage power when the tide is on the ebb, even when confined in narrow channels; to this, however, there are exceptions, as the quantity of water flowing out through a channel may be considerably increased by land drainage, thus causing the efflux to be longer in duration than the influx; and in some places the tide runs out of an estuary for hours longer than it flows into it, the efflux being augmented by floods of rivers and the like. It appears also that the driftage is greater during spring- than neap-tides; and that the maximum driftage occurs when the direction of the incoming tidal current is the same as that of the prevailing winds. We also learn that the "set" of the tidal current inshore depends very much on the shape of the coast-line. If the coast-line is straight, the set of the tide along the shore and outside in the deep water will probably be similar; but if it is indented, or islands lie off the coast, back or "counter-currents" and cross-tides will be induced—which form off-shore banks, and thus lead to various complications. Large rivers may also form counter-currents and off-shore banks.

n illustration of these points the author exhibited a series of grams to show the way in which, when two headlands project at equal distances from the general coast-line, the secondary cur- ts branching from the main tidal current decrease in power from headland first touched, while it is not unusual for a half-tide nter-current to set backwards along the shore from the second dland. Also that when one headland projects much further than other, if the coast-line is formed of soft materials, off-shore als usually are originated, and the secondary currents increase power from the first headland, if it be the longest.

If, however, the longest headland is the second one, and a strait urs at the end of it, as in the English Channel between Portland l and Cape La Hague,[1] the secondary currents increase in intensity rards the strait,—a condition which may account for the peculiar ting of the pebbles on the Chesil Bank, from Bridport to Portland.

Races formed by the meeting of counter-currents with the main al current are always connected with the tail end of an off-shore ık; but whether the bank is due to these causes, or the currents the bank, it is hard to determine.

An island off a headland seems always to have secondary currents sing it on each side, between which a bank grows from the main- d, the counter-currents much resembling those which would have urred were the island connected with the shore.

The flow of a large river generally forms a bank or shoal off its uth at the junction of the river current with that of the tidal rent. About this bank the currents run in various complicated ections; at different heights of the spring- and neap-tides—high- ter spring-tide currents often running right across it.

In a muddy estuary the affluents of the main channel are nearly rariably deflected up stream, showing that the arrangement of the tritus is influenced more by the incoming tidal current than by e efflux. Such tidal accumulations, however, are greatly modified the river floods, as a strong freshet will effect considerable nudation while the tide is out. Denudation may also be effected artificial means, as in the estuary of the Boyne, where, by dicious arrangements, the tidal waters have been made to assume e functions of river freshets.

Scott Russell has shown that at the centre a wave of translation higher, stronger, and swifter, than at its margins. Somewhat in e same way the driftage of the incoming tidal wave is usually uch stronger offshore than it is inshore. This is well known to hermen, who often neglect outlying fishing grounds on account of e additional labour connected with them arising from the augmented locity of the tides.

On a steeply sloping beach the driftage solely due to the tidal ive current is conspicuous when there are no waves formed by the nd. Under these conditions some particles of the beach may be

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[1] The effect here is also augmented by the increased current in the sea between se two headlands due to the "nodal point" of the tide in the English Channel Swanage.

[illegible] in oblique lines, formed of [illegible] in curving lines along the bea [illegible] arrangement in a steeply-slo [illegible] The highest spring-tide limits [illegible] of coarse gravel and shingle. [illegible] quantity being also foun [illegible] This lower band usually tra [illegible] its pebbles may travel upwards [illegible] where they remain until disturbed [illegible]

[illegible] accounts for the accumulation [illegible] against which the curr [illegible] a beach where the groins [illegible] by the groin, while the [illegible] the back wash of the waves [illegible]

[illegible] the materials will be sorted [illegible] that the large fragments [illegible] the finer materials will be de [illegible]

[illegible] similar results: but as some o [illegible] margin of the beach, the [illegible] with the general tidal cu [illegible] carried in obliquely [illegible] narrow, and regu [illegible] and at the head [illegible] than in more open c [illegible] headlands between th [illegible] shingle is not easily deriv [illegible] increase in size from wear a [illegible] sand, in the l [illegible] the tidal current. Th [illegible] along a coast-line, for them [illegible] materials striking obliquel [illegible] above-mentioned results. [illegible] was that of the tidal currents. The [illegible] or augmented by wind-waves.

Wind-waves, as shown by Scott Russell, have usually no driftage power, but locally they may be waves of translation. Incoming tidal waves augmented by wind-waves proceeding in the same direction are capable of performing the maximum amount of driftage on a coast-line; while if the wind opposes the incoming tidal current, it modifies the operation of the tidal waves or may temporarily arrest it altogether.

Tidal-waves and wind-waves when opposed to each other pile the gravel and sand in ridges on the beach. The axes of these ridges and intervening hollows are at right angles to the direction of the opposing currents, when these have equal force and assume an obliquity when one or the other current has a predominant strength.

ind and tidal actions are proceeding in contrary directions,
um power of the wind-waves seems to be exerted during
the tide—especially that of spring-tide—when portions of
are rooted up at depths which are ordinarily undisturbed.
continuous heavy gales blow from a direction oblique
-wave, accumulations of detritus due to the wind-waves
t one side of bays, while other accumulations, due to the
e, will be formed at the opposite side.

accumulations are of slow growth, taking weeks to
ale, however, of forty-eight hours' duration—especially
g-tides—from a direction coinciding with, or obliquely
ith that of the tidal current, will sweep them all away.

t, however, calls for notice here, namely, that the ac-
due to the wind waves cannot be dissipated until
the tidal current are first removed—the latter replen-
rmer as fast as they are removed.

t of these conclusions, detailed observations on the
oast of Ireland were given at too great a length to be
ere, and the author concluded by making the following
—

at the driftage due to the incoming tidal currents is
on in deep water, and also more or less in shallow water.
The driftage due to wind-waves only occurs during gales,
n is only due to the waves that break on the shores.
hat the wind-wave driftage might be prevented from
harbour if a *floating* breakwater were made to cross
from which storms proceed, for a fixed one would
end to cause the harbour to become silted up.

REVIEWS.

D ITS ENVIRONS — HISTORICAL AND SCIENTIFIC. 8vo.
London and Bristol, 1875. Published under the Sanction
al Executive Committee of the British Association.

itish Association in its annual visits to our larger cities
ns has much to answer for in the diffusion of what some
Scepticism, and others a spirit of rational inquiry, it is
trumental in bringing before the public a number of
creating an interest and wholesome stimulus in scien-

entitled "Bristol and its Environs" is a praiseworthy
what may result from such stimulus, and if other local
mmittees follow the example, we may have in time a
ies of hand-books.

gical chapters in this work have been written by Messrs.
y, W. W. Stoddart, and R. Tate, each of whom, apart
ork, has done good service in adding to our knowledge
geology. Few districts have indeed been the subject of
tributions to geological literature as the country around
no city can be prouder of one who devoted so much of

[illegible] the illustration of its geology than Bristol is of William Sanders, whose death we recently recorded. He will have a lasting memorial in his large Map of the Bristol Coal-fields.

But the geology of the country has not been entirely worked out [illegible] nor is Mr. Sanders' map the most detailed geological map that has been produced. Even the one-inch scale map of the Geological Survey exhibits far more detail.[1]

This map (sheet [illegible]) was revised in [illegible] by Mr. H. W. Bristow (Director of the Geological Survey), and the Rhætic or Penarth Beds were inserted and so named by him, after a careful examination of the beds in company with Mr. Etheridge in all the typical localities in South Wales and the South-western counties of England. No mention is made of this, nor of the numerous Horizontal and Vertical Sections published by the Geological Survey.[2]

Mr. Tate expresses his opinion that the White Lias is lithologically and palæontologically Liassic—an opinion which is certainly not supported by facts. The entire absence of Cephalopoda in the White Lias is most marked, and has been well explained by Professor Ramsay on the ground that the physical conditions attending the deposition of the Triassic and Rhætic beds in the British area were those of salt lakes, the fauna of the White Lias being (as Edward Forbes first pointed out) analogous to forms now existing in the Caspian. Subsequent depression led to the influx of the sea, and to the incursion of the *Ammonites*, *Belemnites*, and other forms which characterize the Lias.

Mr. Stoddart has contributed some valuable lists of fossils from the Upper Llandovery and Lower Carboniferous beds. Some objections might be taken to the prominent manner in which the term Devonian is used as an equivalent and in preference to the term Old Red Sandstone, because the contemporaneity of these formations is a subject of considerable dispute. Perhaps, however, when the British Association again meets at Bristol, and a new edition of the work is called for, this great problem may have been solved.

REPORTS AND PROCEEDINGS.

Geological Society of London.—December 15, 1875.—John Evans, Esq., F.R.S., President, in the Chair.

1. "*Notes on the Physical Geology of East Anglia during the Glacial Period.*" By W. H. Penning, Esq., F.G.S.

The author wished it to be understood that his remarks were intended to form a sketch, rather than a detailed account of the subject *to which* they relate. He intended to explain the origin of the so-

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[1] Not only does the *Geological* Survey Map exhibit the lithological subdivisions of the Trias, and the Penarth Beds, but the Faults and Coal-crops, which are not laid down on Mr. Sanders' Map. In the north of England, too, the geology is for the most part surveyed and published on the larger Ordnance Maps, whose scale is six inches to one mile.

[2] See "On the Rhætic or Penarth Beds of the Neighbourhood of Bristol and the South-west of England," by H. W. Bristow, F.R.S. Geol. Mag. 1864, Vol. I. p. [illegible] Report Brit. Assoc. (Bath) for 1864, published 1865.

lled "middle-glacial" gravels and sands, to account for their oc-
rrence in certain areas, and their non-occurrence in others, where
ey might reasonably have been expected. Also to describe a series
gravels of doubtful age and origin in the Cambridge valley.

A short description of the geology and physical features of the
istrict was given, and an inference drawn, from the varying faunas
f the "Crag," that the land was sinking during that era and until
fter the deposition of the Cromer "Forest-bed." Then Arctic con-
itions began to prevail, and the great glacial subsidence com-
enced; the "lower glacial" beds were formed, and succeeded by
large series of false-bedded gravels and sands, with intercalated
atches of unstratified clay. These deposits run up only to a certain
evel, about 300 feet, never quite reaching the top of the Chalk
scarpment, where the overlying Boulder-clay is invariably found
esting on the older rock, without any gravel or sand between. The
uthor inferred from this circumstance that after the deposition of
he "lower" beds, and as submergence went on, the waters of the
orth Sea were again united to those of the Atlantic. A strong
urrent was thus set up, which swept down from the north, bringing
ith it the material of which the gravels are composed, and which
s found to consist of pebbles, all derived from the northern and
astern coasts, mixed with flints from the Chalk. The escarpment
f this formation stood at the time above the water, but when once
ufficiently submerged to admit the water over its lower portions,
he conditions were altered, the current lost its force, and the de-
osition of gravel ceased. An occasional iceberg had dropped its
oad of unstratified clay, which became intercalated with the gravels,
ut the greater number of such bergs were quickly swept away to
he south. Now the waters had access to a larger area, the formation
f gravel was succeeded by that of Boulder-clay, which in the
uthor's opinion is entirely composed of masses of clay inclosing
boulders, brought down and dropped by icebergs *in mass*, which
accounts for its want of stratification.

This Boulder-clay rests evenly on and at the higher level overlaps
the "middle-glacial" sands; it then caps the Chalk escarpment, and
plunges down into the Cambridge valley, even to the present level
of the sea; but in no instance on or beyond the escarpment does any
sand or gravel intervene between it and the older geological for-
mations, although just over the scarp (on the south side) the gravels
run up to an elevation of 300 feet. The gravel-forming currents
were evidently confined to the seaward side of the Chalk range,
and excluded from the Cambridge valley, which is undoubtedly *pre-
glacial*, and which formed at the time a large inlet, land-locked on
every side but one, discharging its waters through the opening now
occupied by the estuary of "The Wash."

In the Cambridge valley there are sheets of river-gravel of recent
date, some patches of doubtful age, but not traceable under the
Boulder-clay, and an elongated series of gravels at a level of 20 to
0 feet above the present level of the Cam. These are in some parts
distant from the present course of the river, and present a striking

resemblance to glacial gravels; but as they here and there contain recent shells, and taking into consideration their uniformity of level, the author concludes that they indicate an ancient course of the River Cam.

The other conclusions arrived at, after mature consideration of all the evidence hitherto obtained, are—that a gradual passage will be found to exist from the base of the Crag up to and through the drift deposits to those of recent date; that in East Anglia we have evidence of but one, and that a gradual, period of glacial submergence, succeeded by a corresponding movement of re-elevation; and that there are no "middle-glacial" deposits whatever within the area of the Cambridge valley.

2. "Denuding Agencies and Geological Deposition under the Flow of Ice and Water, with the Laws which regulate these actions, and the special bearing on river-action, of observations on the Mississippi and other great rivers, and their present and past Meteorological conditions, and similar remarks on Marine Deposits, illustrated by the Irish Sea and the Chesil Beach." By A. Tylor, Esq., F.G.S.[1]

The author's remarks were illustrated by diagrams of carefully measured sections, of instances of deposition and denudation. From these he inferred that the present contours of hills were formed in a previous Pluvial Period, when rivers and springs, winds, currents, and tides, were of greater force than at the present time. He thought the immense size, height and position of Quaternary Gravels, when compared with recent deposits, afforded evidence of a rainy more than an icy period.

It was remarkable that the great Playfair, the original advocate of Land Ice as a geological agent, was not acknowledged as the author of this great discovery by either Agassiz, Lyell, J. Croll or James Geikie. His merit was, however, fully admitted by d'Archiac and the late Professor James Forbes, of Edinburgh.

One of Playfair's original and accurate remarks in 1813 was that, "after glaciers, torrents were the most powerful agents of denudation."

Mr. Tylor illustrated his paper by accurate drawings of Black Gang Chine; part of the Undercliff, Isle of Wight; Oliver's Mount, near Scarborough; Fairlight and Ecclesbourne Glen, near Hastings; the Rhondda Valley, S. Wales, etc., to show that the contours in such strata could only have been formed in a wet climate. These do not now change perceptibly, except in wet districts, as S. Wales. The writer then compared the 16 inches of rain and snow in winter, with the 64 inches in summer in Westmoreland, and also remarked that the 30 inches rain and snow in winter in Switzerland only rising to 42 inches in summer, show the probability that rainfall was much greater everywhere in the whole year than snow—snow being probably limited to 9 months of winter alone, even in the Glacial Period. Both rain and snow diminished in quantity at heights of more than 2000 feet above the level of the sea in Westmoreland, and above 6000 feet in Switzerland. Mr. Tylor concluded that as ischarge of the Rhine below the Lake of Geneva was 35 inches, he discharge of the Mississippi only 7 inches, that the little s of discharge from glacier-rivers might be only due to the tion of the snow-covered land. He explained the serrated form e higher Swiss mountains by supposing in the Glacial Period the ' and ice were only formed at comparatively low levels, all the ur as it arrived being absorbed by clouds discharging near the of the sea. Nordenskiöld remarks that in the 80th parallel of ide the hills near the coast are bare of snow in summer, while low ground near the sea is always encumbered with ice and r. The same cause produces early abstraction of vapour, and enable the Poles to be free from ice. The ice-cap must have much thicker at the 70th parallel than further North.

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[1] This abstract of Mr. Tylor's paper has been furnished by the author, and is inserted by his special desire as more fully expressing his views.—Edit. Geol. Mag.

ith regard to his description of the Quaternary deposits, Pror Prestwich first reduced these strata to systematic order. The er differed from him as to climate, the divisions of the beds, and ge of the valleys, etc. These strata have a local character in land, but in other parts of the world Mr. Belt has found the rary to be the case.

ith regard to Dana's River Mississippi in Quaternary times 50 s wide, Mr. Tylor thought a river 50 times as wide as the pre- Mississippi must be 2½ times as deep, and according to his ula would have 5 times the present velocity. Such a river ld want 625 times the present snowfall or rainfall to fill it. melting of Dana's "Great Glacier" would therefore have the acter of a *débacle*, without the name. The old Mississippi would e exhausted such an ice-cap almost in 30 years.

he depression of the Mississippi Valley, supposed by Dana to have rred in the Gravel Period, should be proved by examination n flexures to have actually occurred, as the land is never raised lepressed without a series of flexures being formed; interference h the regularity of the slopes and junctions of modern main and utary rivers was referred to as not affording evidence of any urbance. Mr. Tylor referred to the double system of flexures of ation in the Wealden area, which he had shown, in 1868, were fractures, as Hopkins had thought. Flexures had determined the rse of the Wealden rivers. In that area valleys and gorges were duced actually resulting in the Quaternary Period from denuda-. A north-and-south flexure of 1000 feet in a mile had occurred uildford, and had caused the gorge of the Wey at the point where strata had also been especially depressed by an east-and-west le flexure of small amount per mile, but extending over a length 0 miles.

he contour of a section, measured by A. Tylor, of some remark- marine fossiliferous gravels at Coalbrook Dale, was compared h the contour of the modern Chesil Beach. This remarkable of isolated marine gravels in the Severn Valley apparently ned of *remaniè'd* fluviatile gravel at a height of 200 feet above sea, without trace of similar beds between Bridgnorth and the was then dwelt upon, and the Moel Tryfaen beds were described, occurring at heights much above the Welsh Lakes, which were, however, not occupied by marine beds.

The writer expressed his regret that when Mr. Trimmer found, in 1831, the markings or scratches, which he rightly pronounced glacial, made distinctly on the face of the Tryfaen Rocks, and covered by the fossiliferous marine drift, he did not infer that a Glacial Period had once existed in Wales. The great discovery was made by Agassiz in 1837 that there was an Ice Period at one time almost all over the world.

Some of the best examples of the rapid formation of a recent fluviatile stratum were in India. A deposit was there described made by but a small mountain stream measuring a million cubic feet in a month.

Rivers flowing in uniform motion for hundreds of miles, often depositing but a small portion of sand and mud, carry out a great mass of solid matter in suspension, and along their river channels, and push the material into the sea, furnishing material for marine littoral deposits.

The case of the Danube bar, where a rapid denudation 650 feet wide has been produced by artificial piers arranged by Sir C. Hartley so as to concentrate the river-current and make an opposite current from the sea, was referred to.

Sir H. T. De la Beche observed that the dry land valleys along the English coast were not prolonged into the Channel. The source of the material to fill them must have been the sands brought in from deeper water or from the rivers.

The writer pointed to the immense cuts out of solid strata or rocks in the estuaries of the Thames, Seine, and Severn, to show how the alternate and often opposite action of the river and tide favoured denudation. The sea alone could not penetrate an iron-bound coast in this manner.

The sea throws up beaches all along the coast, as well as littoral deposits. Chesil Beach is a conspicuous example, with its lagoons behind, and its form approaching a binomial curve, to which all beaches approximate. The Rio Grande Beach, 100 miles long, 10 miles wide, inclosing a fresh-water lagoon 20 miles wide, 100 miles long, was referred to as a recent deposit, like that, on a small scale, at Shoreham, near Brighton.

A drawing to scale showed that the course of the Chesil Beach could be closely represented by a binomial curve.

The writer had previously applied this curve to indicate the true form of hills, when not disturbed by beds of unequal hardness or permeability. The lower part of this curve is a parabola, and the longitudinal sections of large navigable rivers (of which the Ganges is a good instance) follow this curve. The law of uniform motion of rivers and the effect of weight and slope on velocity were illustrated by diagrams.

Marine deposits and marine denudation may be well observed in many real instances on our coast. The writer was unable to find a good example of a plane of marine denudation, a term in general use among geologists; but he had found in the Estuary of the La

a that the depth at any point over an area of 6000 square miles not more than 30 feet, nor less than 8 feet, so that there was not at particular instance of an estuary much deviation from a plane. Ir. Tylor does not think the plane of denudation is a good term. he Irish Sea, of which he produced a section and plan, the width he central gorge below 50 fathoms varies with the width of the nnel from shore to shore. The curve of denudation is a more ct phrase for the section of the sea than the plane.

Ir. Tylor exhibited drawings and observations to prove that the ocity of the tide over a district of 120,000 square miles of sea tom near Scilly is about 1 mile an hour, the mean depth of the nnel averaging 67 fathoms.

By the composition of forces the velocity of the tide at springs is reased in an eastward course to six knots an hour near the annel Islands, or south of the English Channel, where the Channel nly 12 fathoms deep on the average.

The tide in the more northern part of the English Channel was wn from observation to increase in a regular ratio from one to se knots an hour going eastward, as the depth of the sea decreased m 60 fathoms to 20 fathoms. That is, as the water decreased in oth, it increased in velocity.

Mr. Tylor supported the view that the central mass of the Atlantic ter was moved bodily at $\frac{1}{10}$th of a mile per hour, alternately east l west every six hours, and that by this rhythmic movement an pulse was communicated to the water in the Irish Sea, almost tantaneously, as if through a solid body. He believed he had oved this transmission because the tide turned every six hours at e same time in all parts of the Irish Channel, even in remote orecambe Bay. There must have been a vibration propagated with e velocity almost of light from the centre to the sides of the Atlantic. The height of high water and the time of high and low water must affected by local influences only, for high and low water did not incide with the turn of the tide. There does not seem any evidence a tidal wave really bringing high water with it (except in a nnel-shaped estuary). If it were so, high water ought always to synchronous at both ends of the Irish Channel; but the fact is at it is high water at one end of the Irish Channel when it is low ter at the other. High and low water are only consequences of e act of partly filling and emptying an irregular channel by tidal pulses, and vary in time and height.

The author does not believe in the Tidal Wave as generally scribed by existing writers, or as a thin sheet of surface-water oving at an immense velocity, according to the theory of Dr. hmick, the latest writer on the Tides. He thinks, on the conary, all the tidal effects could be produced in a model by moving e deep (tidal) impulse-giving water alternately and oppositely. central horizontal movement of $\frac{1}{100}$-inch in the deep central vity of the model would move the water at the shallow extremies one inch, raising and lowering the level of the water at the tremities, without vertical movement of the central mass.

ON THE *COTYLEDERMIDÆ*.

SIR,—The December Number of your MAGAZINE contains a letter from Mr. Chas. Moore, of Bath, purporting to be a notice of "the genera *Plicatocrinus*, *Cotylederma*, and *Solanocrinus*," of which he tells us next to nothing, but attempts to make it appear that I made an erroneous diagnosis of the Cotyledermm I described in the October Number of the MAGAZINE, and gives an inaccurate account of private conversations which ought not to have been published. Let me narrate, by way of explanation, what did occur.

Late in the evening, at the Conversazione held in Colston Hall on the 27th August last, during the Meeting of the British Association at Bristol, my friend Mr. F. Longe, F.G.S., met me in the room, and told me he had found a new fossil in the Lias near Charmouth, and wished to have my opinion upon it. Taking the specimen from his pocket, he said, "Tell me what it is." I replied, "The light is now so bad that I am afraid I cannot see that small dark object," but placing it under the dim twinkle of an expiring lamp to examine it, I said, "From what I can make out, it resembles a *Balanus*, for it has adhered to something, has a bent body composed of unequal longitudinal pieces, and has an opening at the top, but the pieces or plates are different in structure and mode of junction from those of any *Balanus* I know. If you will let me have the specimen again when I have a good light, and my pocket lens, to help me, I will endeavour to make out more about it."

On the following Monday morning I met Mr. C. Moore in one of the railway carriages between Bath and Bristol. He took Mr. Longe's fossil from his pocket, and showed it to me. I told him I had seen it on Friday evening at the Conversazione, and repeated what I had said to Mr. Longe about it (but added that I had seen it in so dim a light it was impossible to make out anything beyond its general outline). I then carefully examined the fossil with my lens, and we talked over the very singular character of the group *Cotyledermidæ*, to which it evidently belonged, and about the structure of which, from that conversation, it appeared we had everything to learn. Mr. C. Moore said he thought he had found separate plates of the same fossil, which however he never showed to me in his museum. He is further mistaken in saying that I had the advantage of consulting Deslongchamps' "Memoire sur le couche à *Lèptæna*," which I did not see until after my notice had appeared in the MAGAZINE in October, otherwise I should have found that the author had referred this form of COTYLEDERMIDÆ to Münster's genus *Plicatocrinus*, and that on the first sight of the fossil, Deslongchamps had the same impression of its form and affinities as myself; for he says at p. 45: "It has the aspect of a small *Balanus*, and like the *Balanus* is formed of unequal longitudinal plates; but here the resemblance ceases: the plates, which are thick and flat, have their borders placed in simple juxtaposition, and not united by a serrated suture." From the foregoing, it is evident I gave no opinion on the subject, and this Mr. C. Moore knew from myself, as I told him what I had said to Mr. Longe; therefore I consider it very unfair on his part to state that I had made an incorrect diagnosis of "a group of fossils, on which I had been so long at work," merely to show that the correction of the error was due to himself.

Cheltenham, *4th Jan.*, 1876. Thomas Wright, M.D.

UPPER BOULDER-CLAY OF THE N.W. OF ENGLAND.[1]

Sir,—I am sorry that the very eminent glacialist, Mr. Kinahan, did not see a better specimen of the above deposit than that mentioned in his article.[2] I have been familiar with it, for many years, in the flat and low-lying districts of Shropshire, Cheshire, Lancashire, and West Cumberland. It is the best-defined, most persistently uniform in its character, and horizontally-continuous of any glacial deposit I have seen. It likewise contains the largest per-centage of flattened pebbles with parallel and perfectly-preserved striæ. With regard to the drifts of the Isle of Man, I think they ought to be compared with the magnificent normal sections occurring on the opposite sea-coast of Cumberland, between Maryport and St. Bees, but especially between Ravenglass and Millom. For information on the above subjects, see Geol. Mag. for Dec. 1870, June and July, 1871, and Sept. 1872. See also Quart. Journal Geol. Soc., vol. xxv. p. 407; vol. xxviii. p. 388; and vol. xxx. p. 181.

D. Mackintosh.

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[1] This letter has been accidentally held over.—Edit. Geol. Mag.

[2] Geol. Mag. 1875, Decade II. Vol. II. p. 547.

THE SCARLE BORING, LINCOLNSHIRE.

Sir,—It may interest your readers to learn that this deep boring has at length entered the Coal-measures at a depth of 1,900 feet, after passing through strata from the Lower Lias downwards to the Coal-measures. The Permian beds were found of greater thickness than was expected, and for some time disappointed the expectations of those who hoped the Coal-measures would be reached at a less depth than has actually proved to be the case. The core which was sent to me last week by Mr. J. T. Boot, Mining Engineer, who has superintended the work, consists of grey fine-grained grit, slightly micaceous, containing carbonized plants, but too much rubbed for determination. It came from a depth of 1,906 feet. Judging from the lamination, the dip of the beds is moderate. The boring reflects great credit on the Diamond-Boring Company, and upon the adventurers, who, through much discouragement, have persevered; and it is to be hoped that ere the experiment is abandoned, an actual coal-seam will be pierced through.

I hope to be able to draw up a detailed account of this most interesting attempt to reach coal far beyond the district in which it is worked.

Edward Hull.

Geological Survey of Ireland,
14, Hume Street, Dublin, 17 *Jan.* 1876.

Miscellaneous.—Prof. A. E. Nordenskiöld and the Swedish Expedition to the Polar Sea. An Imperial ordinance was officially published at St. Petersburg, Jan. 1st, 1876, directing that the thanks of the Russian Government be conveyed to the Swedish Professor Nordenskiöld, for his exploration of the Polar Sea up to the Yenisei River.

OBITUARY.

GEORGE POULETT-SCROPE, F.R.S., F.G.S.[1]

BORN, 10 MARCH, 1797. DIED, 19 JANUARY, 1876.

One by one the last few strands are being severed, which connected the younger school of Geologists with the early masters of their science, whose large and comprehensive views tended so much to render Geology what it now undoubtedly is, the most popular science of the day. Those who had the good fortune to know Mr. Poulett Scrope personally, as a scientific man, were few, but they can testify to the broadness of his scientific views, as well as to the nobleness of his character. Those who knew him by his published works (on 'Volcanos,' etc.) were many, and none can doubt the wide influence of his writings on the current of geological thought to-day.

Many of the most advanced propositions in geology may be traced back in time to Mr. Poulett Scrope's earlier works.

Thus, for example: That the foliation in metamorphic schists, no less than the cleavage of the finer slate-rocks, was due to the squeezing of their crystalline or semi-crystalline particles while in a viscous state ('Volcanos,' 1825).[2]

That most valleys are due to subaerial denudation ('Geology and Volcanos of Central France,' 1827).[3]

That many deposits, hitherto referred to different geological ages, may have been accumulated *contemporaneously* in contiguous areas ('Volcanos,' 1825, p. 239).

That volcanic cones are not due to the blister-like elevation of the superjacent strata, as advocated by Humboldt, von Buch, and Elie de Beaumont; but to the accumulation, above the fissure or vent, of ejected materials, as ashes, cinders, scoriæ, pumice, and other loose materials interstratified with beds of lava.[4]

That steam is the great dynamical agent in all volcanic outbursts; and that it also fills the interstices of all fluid lavas.

As an old Member of Parliament from 1833–1868 (a period of thirty-five years), Mr. Scrope was personally known to many and sincerely esteemed by all his colleagues on the Liberal benches.

To the pages of this MAGAZINE he has been a frequent contributor up to the last.

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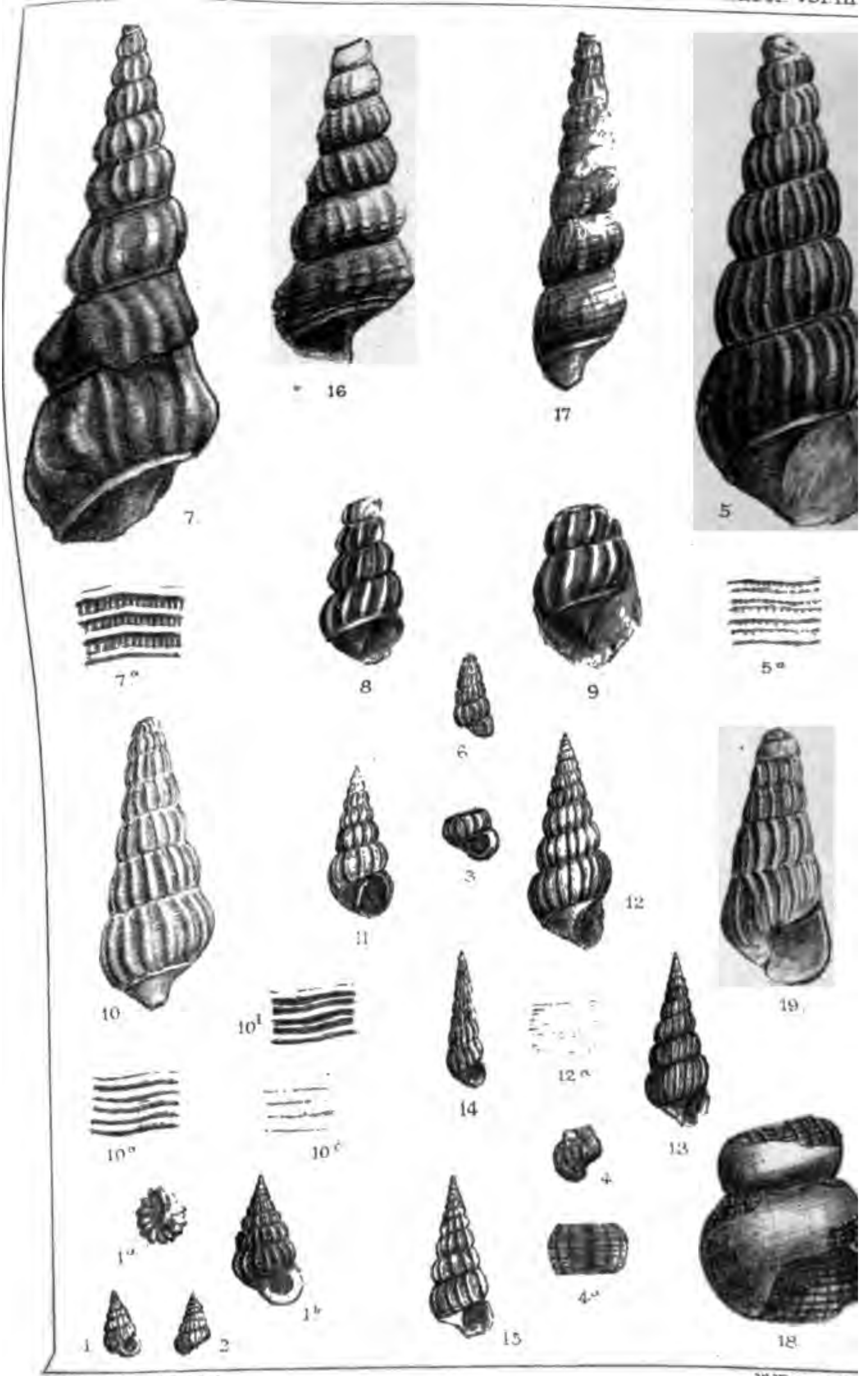
[1] [A full notice of Mr. Poulett Scrope, with a Portrait, will be found in the GEOL. MAG. 1870, Vol. VII. p. 193.] See also notices in the 'Academy,' 'Nature' and the 'Athenæum,' for 29 January, 1876.

[2] 'Geologist,' 1858, vol. i. p. 362.

[3] GEOL. MAG. 1866, Vol. III. p. 193.

[4] 'Volcanos,' 1825; Quart. Journ. Geol. Soc. 1856, p. 337.



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Cretaceous Scalidæ.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE II. VOL. III.

No. III.—MARCH, 1876.

ORIGINAL ARTICLES.

I.—SUBAERIAL DENUDATION *versus* GLACIAL EROSION.

By W. GUNN,
Of H. M. Geological Survey of England and Wales.

MY friend and colleague, Mr. Goodchild, has contributed to the GEOL. MAG. for July, August and October last, articles on Glacial Erosion in the Yorkshire Dale District, in order to evoke criticism; and as no one who knows the ground has come forward to reply in detail to his arguments, I am induced to offer some notes of my own on the subject.[1]

Much of both his articles is based on the supposed fact that "under the influence of the weather, limestone, as is well known, often disappears with great rapidity" (p. 326); and "disappears in this way faster than any other rock" (pp. 327, 359, 362, 488, 491). He says (p. 327): "It will then readily be admitted by most geologists that under purely atmospheric conditions the rock that tends to disappear the fastest is limestone; next to this shale; and the slowest of all to weather away is sandstone." I, for one, cannot admit this, nor do I think most geologists would admit it. Jukes certainly thought the Carboniferous Limestone of Ireland wasted faster in this way than the Old Red Sandstone;[2] but he says, "Any bands of soft shales and clays would of course yield more rapidly than the sandstones, or perhaps even than the limestones, and form corresponding low lands and valleys."[3] Lyell, writing of the raised sea-beaches of the Gulf of St. Lawrence, 60 feet above present highest tides, says: "In the North American beaches above mentioned rounded fragments of limestone have been found perforated by *lithodomi;* and holes drilled by the same mollusks have been detected in the columnar rocks or 'flower pots,' showing that there has been no great amount of atmospheric decomposition on the surface, or the cavities alluded to would have disappeared."[4] This shows that limestone does not everywhere waste with great rapidity. Further on the same author says, "Notwithstanding the enduring nature of the marks left by littoral action on calcareous rocks, we can by no means detect sea-beaches and inland cliffs everywhere, even in Sicily and the Morea. On the contrary, they are, upon the and shale. I refrain from referring to the numerous limestone ravines to be found in many other places.

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[1] The author wishes to state, that, when this article was written, the January Number had not appeared, and he was unaware of the fact that his colleague, Mr. Hugh Miller, had written upon the subject (see GEOL. MAG. January, 1876, p. 23).

[2] Jukes and Geikie, Manual, third ed., p. 455.

[3] Op. cit. p. 456.

[4] Elements, sixth ed., p. 78.

We get evidence of the comparative rates of weathering of limestone and sandstone in buildings. Mr. A. B. Wynne, in a very suggestive paper on Denudation, states that "atmospheric action is sometimes slighter upon limestone than upon other rocks, as may be witnessed in ruins and old buildings, the masonry of which includes both limestone and sandstone."[1] Sir Henry De la Beche says the Carboniferous Limestone of the South-west of England is both a hard and durable material, while few of the sandstones of the carbonaceous series can be considered durable except those in which the siliceous matter so abounds as to render them almost cherty.[2] Prof. Ramsay says: "The Carboniferous Limestone also is an exceedingly durable stone. . . . . . In Caernarvon Castle the preservation of this limestone is well shown. The Castle is built of layers of limestone and sandstone, the sandstone having been chiefly derived from the Millstone Grit, and the limestone from quarries in Anglesey. . . . . . The limestone has best stood the weather."[3]

I think I have now shown that Mr. Goodchild is mistaken about the comparative rates at which limestone, sandstone, and shale are denuded under purely atmospheric conditions, and that the order is the same for rain and frost as that he gives for mechanical erosion in a stream, viz.: "Shale goes fastest; next to this come the thinner-bedded sandstones; and longest of all in being worn away are the blocky sandstones and the purer kinds of limestone" (p. 327). I think that some of the hard blocky sandstones of these dales would stand out longer against atmospheric denudation than even the hardest limestone.

I do not see that the regular form of the scars and their parallelism to others above and below is a special difficulty for subaerialists, for however first formed, they would be pretty evenly cut back all along by rain and frost, as mentioned by Messrs. Bonney and Greenwood, and so roughly preserve their parallelism to the stream and to one another. And if we suppose the scars had no pre-glacial existence, the beds which now form scars must have outcropped along the sides of the valleys pretty regularly and roughly parallel to each other, unless it is supposed that the ice acted on a set of very irregular outcrops and denuded some very much more than others, in order to produce the parallelism we see—a supposition which seems very unlikely; so that the *parallelism* of the scars, if they *have* been formed by ice-action, is not *directly* due to such action.

Nor does the correspondence of the scars on one side of a dale with those on the other present any special difficulty. Where the valley is pretty straight, we should expect the scars to be roughly straight on both sides; where there is a curve in the valley, we should expect the outlines to be concave on one side and convex on the other. But the curves of the valley as a whole may not exactly

[1] Geol. Mag. Vol. IV. p. 7.

[2] Geological Report on Cornwall and Devon, p. 490.

[3] Phys. Geol. and Geog. of Great Britain, third ed., pp. 316, 317.

correspond to those of the present stream, for those who hold that the river formed its valley cannot suppose that it always ran exactly along its present line.

The general absence on these limestone terraces of much *débris* from the higher ground may perhaps be explained in this way:—The bed immediately above the limestone is shale, generally forming a slope above the limestone terrace, and the decomposition of this produces a clay pretty easily carried off in minute portions by heavy rains. That we do not find much of this on the terrace may be owing to the fact that the clay is carried down with the rain through the numerous joints of the limestone. I remember a distinguished geologist once remarked to me on the comparative freedom from drift of limestone areas when compared with areas of other rocks similarly situated. May not drift disappear more rapidly from limestone on account of the easy passage of muddy water downwards, and leave but a few scattered boulders here and there to pose the geological surveyor who does not know in some cases if he should consider them the remains of a drift covering or the remnants of beds which have been denuded off the limestone? Of course I may admit that these terraces were probably swept bare of loose rock by the ice-sheet, and yet be unable to accept the view that the terraces themselves were formed by that force.

Next with respect to the general weathering of the terrace and the formation of swallow-holes. We are told that the limestone of the terrace is uniformly weathered (p. 324); that the part nearest the marginal scar usually exhibits no greater amount of weathering than does the innermost part close to where the next bed above comes on (p. 358). I do not think I have ever seen the whole known thickness of a limestone bed in one of the scars unless where the shale bed came on immediately above, so that there was no perceptible terrace. Where the terrace is wide, there is generally nothing like the whole thickness to be got near the marginal scar; so that if that part is not more weathered, at least it has been more denuded than the part nearer the inner margin of the terrace.

Mr. Goodchild supposes that by Glacial Erosion all swallow-holes were removed from the low ground, while many were left on the high ground. I think another explanation may be given of the fewness of swallow-holes on the low limestone terraces. It is well known that ordinary rain water has but a slight dissolving power on limestone, which is much increased if the water passes through peat or other decaying vegetation, and thus absorbs much carbonic acid.[1] Now there is little or no peat on the low ground, while there is abundance on the high ground, much of the surface of the highest limestone terraces being covered with it; and I can testify that the peat-covered limestone has swallow-holes sown broadcast over it, and that they are not confined to the inner margin of the terrace in such cases. Most of these swallow-holes could not have been formed by streams, but by the dissolving action of the water that drains from a limited area like those mentioned by Mr. Bonney.[2]

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[1] Lyell, Elements, *sixth ed., pp. 42, 363*; Jukes and Geikie, p. 397.

[2] *Geol. Mag. Sept. 1875, p. 427.*

According to Mr. Goodchild, subaerial denudation in forming swallow-holes by the action of streams should give rise to a series of ravines extending across the whole width of the terrace (p. 359), and as on the high ground "a considerable portion of the pre-glacially weathered rock was left" (p. 361), we ought there to find the remains of such ravines. Yet it is true enough, as he says, they are very rare. I know of one in Arkindale, about 150 yards long, which, however, does not stretch all across the outcrop of limestone. It is more common to find, beyond the place where a stream now sinks, an irregular line of swallow-holes; which shows that the stream generally finds some place to sink in, higher up in its course, before it can cut its way back. Thus a new swallow-hole is formed and the old one is disused; and if we are only granted a small portion of the enormous dissolving power of rain on limestone rocks claimed by Mr. Goodchild, the swallow-holes may disappear by general waste of the surface ere the scar is cut back to them.

The argument against the fluvial origin of these rock ledges, "that many of them are situated a thousand feet above any stream that could possibly have produced them" (pp. 324, 328, 359), seems to me to tell against their glacial origin; for the highest of the principal limestone terraces—that formed by the Main Limestone—is generally the largest of any, and its scar the most continuous, while it is situated at a height where the ice could have little abrading power, and where, in Mr. Goodchild's opinion, "a considerable portion of the pre-glacially weathered rock was left" (p. 361); therefore this terrace should be much less perfect than the lower ones.

I do not see why a great part of many of these rock terraces may not have had a fluvial origin. Over the greater part of the district the rocks are only very slightly inclined from the horizontal; and when the valleys began to be formed, the slope of the ground and dip of the beds very nearly coincided, so that a river must have run for long distances on the same bed. And *pace* Mr. Goodchild, streams generally in these Yorkshire Dales do not now cut down rocks to one level, as the sea does (p. 356); and as it would "be difficult to find one of the Dale District terraces that is not more or less inclined," so it would be difficult to find in the same district any considerable length of river cliff that is shorn off to one level. Of course I do not suppose that a river could form such scars and terraces as those near Carperby (p. 327); nor do I see how they could have been formed by Glacial Erosion, for it is admitted that "where the ice moved across the outcrops of the beds, the scars and terraces are either slightly developed or else are wanting altogether" (p. 486); and I do not think the ice would have gone out of its straight path in order to coast the outcrops here. There are several other examples of lines of scars and terraces in these dales, in steeply dipping rocks, that could not have been formed by the action of streams; nor by erosive action of ice, unless it formed scars when cutting across the edges of the beds; hence one is forced to look elsewhere for the origin of such.

In modern ravines, such as those Mr. Goodchild has so well described, where several feet of shale are interposed between two hard beds of limestone or sandstone, forming two waterfalls pretty close together, we often find that some distance below the lowest waterfall there are two separate scars with a little terrace between them. How has this been formed? Clearly not by the stream alone, for it most likely did not run at all where we now see the little terrace on either side; but the upper hard bed, having been exposed longest to subaerial action, is worn back further than the lower one, while the soft shale between, being worn away faster than either, has left a terrace. Again, where a hard bed dipping at a high angle crosses the course of a stream, we see that atmospheric denudation has so acted on the banks of the beck as to leave the hard bed in relief as a ridge, the upper slope of which, from the weathering away of the soft bed above, tends to coincide with the dip, and thus is formed a terrace sloping at a considerable angle from the horizontal. These examples show how scars and terraces may be initiated by subaerial denudation. Thus the fact that "where the rocks are much disturbed, the characteristic terraces usually keep to the same bed through all its variations of position and inclination" (pp. 324, 328), is in my view in favour of their being in the main the work of rain and frost, and against their being formed by erosion of ice, which could not act equally on the same bed in all positions.

I have, I think, before shown that limestone, as a rule, is not more easily weathered than the sandstones and shales with which it is associated; and as it is by far the most important rock (p. 324), and forms the thickest and most massive beds (and according to my view generally the hardest), we need not be surprised that the scars formed by it are usually more perfect than those of the sandstones. Of course there are exceptions to this rule. The sandstones are generally laminated, and do not form thick beds; but where it happens that a thin limestone is superimposed on a thick hard bed of sandstone, as near Preston in Wensleydale, the limestone and sandstone in places form separate features, the sandstone being most prominent. It seems strange that in these articles so much is said about springs and streams, which can only act along lines, and so little about rain and frost, whose action is universal. (See Greenwood's "Rain and Rivers," and Lyell's "Principles.")

It is unnecessary for me to show how scars once formed will recede as the result of these agencies. Their effects have been well shown by many geologists, of which a pretty full list is given in Mr. Whitaker's admirable paper (Geol. Mag. Vol. IV. pp. 448—450).

That there was extensive denudation during the Glacial Period all must admit; and that the ice-sheet would sweep away loose surface *débris*, and here and there a talus temporarily accumulated at the base of a scar,[1] is not hard to see; and it may have partially stripped of shale some of the terraces. But if it had worn back or formed the scars, we ought to find ice-marks along their faces. But do we? The presence of such ice-markings would not prove that the scars were formed by glacial erosion, but their absence tells strongly against the theory. The Shap granite of Wastdale Crag being nearly exposed on all sides may have had a larger quantity of weathered and loose rock in proportion to its area than many other districts, and it seems to have lain in the path of the ice-sheet that went over Stainmore, so it may have suffered greater denudation. The old pre-glacial alluvia and river-gravels of these Dales must have all been swept away, and haveh elped to swell considerably the mass of glacial drift. They may have been much more extensive than those now existing (some of the present gravel terraces are 70ft. to 80ft. above the river), and may have rivalled in height above the streams those of the Weald as described by Messrs. Foster and Topley.

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[1] It is possible that a scar of limestone or sandstone, however first originated, may in certain situations accumulate *débris* faster than subaerial agencies can remove it, and that old pre-glacial scars were uncovered by glacial erosion. On the other hand, as one of the results of the Glacial Period, we have, as seen in railway cuttings, old scars covered up by *glacial drift, and being* gradually uncovered by rain and rivers.

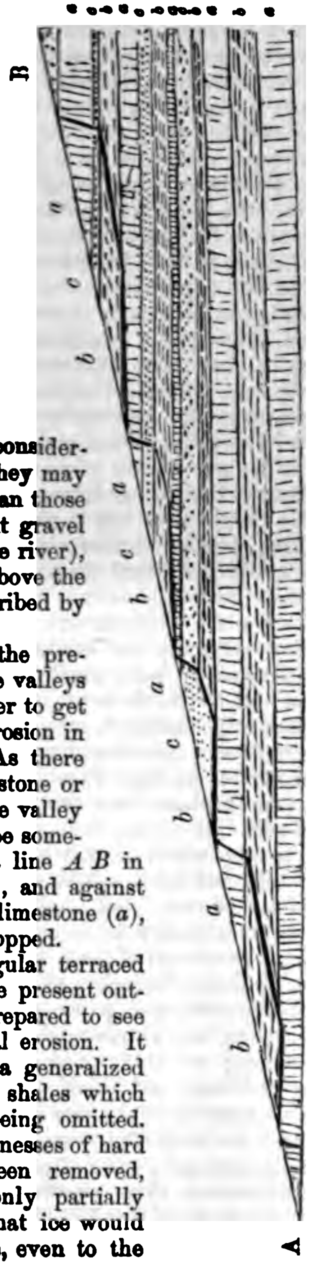
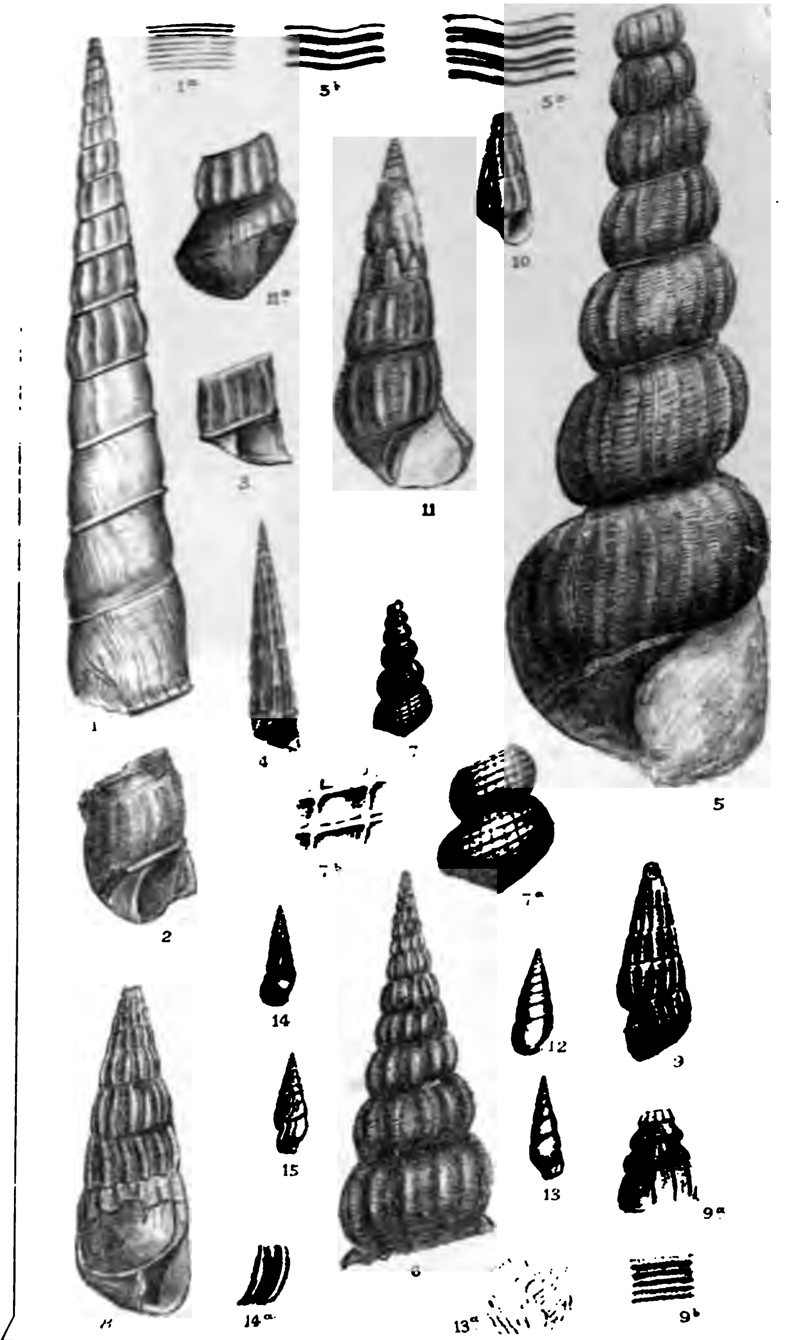


Fig. 2.—Generalized Section illustrating the effects of Glacial Erosion.
a. Limestone. *b.* Shale. *c.* Sandstone.

Suppose we attempt to restore the pre-glacial form of the ground in these valleys according to Mr. Goodchild, in order to get at the *modus operandi* of glacial erosion in forming the scars and terraces. As there were none of these, either of limestone or sandstone (p. 362), each side of the valley must have had a pretty regular slope somewhat like that of the light straight line *A B* in the accompanying Figure (Fig. 2), and against this surface the different beds of limestone (*a*), sandstone (*c*), and shale (*b*), out-cropped.

Now let us add the thick irregular terraced line to represent approximately the present outline of the ground, and we are prepared to see what rocks were removed by glacial erosion. It must be understood that this is a generalized section, certain sandstones in the shales which occasionally form minor scarps being omitted. Now we see at once that great thicknesses of hard sandstone and limestone have been removed, leaving the shale next below only partially denuded. It seems more likely that ice would *have cut further* down in the shale, even to the



J. S. Gardner del et lith W. West & Co. imp

Gault. Scalidæ etc. from Folkestone.

next hard bed, thus making the terrace of limestone below extend right up to the face of the scar, which would be formed not only by the limestone and sandstone, but also by the shale, the whole of which would be in the base of the scar.

If the Glacial Erosion theory of the origin of these rock-terraces is the true one, we ought to find similar features in districts where glaciers now abound, and we should find them especially well marked where a glacier is known to have recently retreated up its valley. I cannot find that any of our noted glacialists have remarked on such features. We read much of *roches moutonnées*, and mamillated, smoothed and rounded surfaces, but nothing of straight lines of scars and flat terraces. Prof. Ramsay says, "The rocks in the valley over which it slides become smoothed and polished—not flatly, but in flowing lines."[1] Hence the sharp edges of the scars and the flatness of the terraces in the Yorkshire Dales tell against the Glacial Erosion theory.

Features similar to those described so often above can be formed without the help of glacial erosion, for they are found in parts of the world where there are no traces of glacial action. It has been well said by one in replying to somewhat similar views of glacial erosion advanced by the Rev. O. Fisher and Mr. Mackintosh in former numbers of this MAGAZINE:—"It is unwise to accept agencies of limited applicability to explain universally occurring phenomena when we have agencies *everywhere* active, and which are believed, *given sufficient time*, to be equal to the work performed."[2]

I had intended criticising the paper on "Coums, Corries, or Cirques," but this article has already run to great length, so I refrain from doing so here. My purpose is served if I have shown that the argument in favour of the origin of these characteristic features of the Yorkshire Dales by Glacial Erosion is not nearly so strong as it has been represented, and that ordinary Subaerial Denudation does not "fail completely" to account for them.

II.—ON CRETACEOUS GASTEROPODA.—Family *SCALIDÆ*.

By J. STARKIE GARDNER, F.G.S.

(PLATES III AND IV.)

(*Continued from the February Number, page* 78.)

SCALARIA CLEMENTINA, Mich. Gault. Plate IV. Figs. 1, 2, 3, 4.

Shell very elongated, angle less than 10°, composed of eighteen or possibly more elevated, squareish whorls, which slightly diminish in convexity in descending the spire; apex acuminate (Plate IV. Fig. 4); ribs ten or eleven, straight or slightly sinuous, linear near the apex, but becoming more prominent and obtuse with the growth of the shell, the intervening spaces nearly flat. The ribs, in common with those of other Cretaceous Scalidæ, are never so clean and sharp as in the recent species, but have more the appearance of folds. In some of the larger specimens the ribs disappear altogether on the last three or four whorls, and are represented only by more or less strongly marked lines (Plate IV. Fig. 1). The striæ are fine and numerous (Plate IV. Fig. 1*a*), fifty or sixty on each whorl. The sutures are very distinct, the margins of the whorls being usually raised into a roll-like collar. This collar appears on the last whorl in the form of a conspicuous spiral keel, against which the ribs terminate, leaving the base of the whorl, which is very flat, marked with striæ and lines of growth only. The aperture is oval or quadrate, and in the perfect state was probably terminated anteriorly in a sort of beak (Plate IV. Figs. 2 and 3); lips thin; columella smooth. The cast of the shell generally preserves the rib marks, except near the apex, where the whorls are smooth and very rounded.

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[1] Phys. Geol. and Geog. of Great Britain, third ed., p. 141.

[2] Topley, GEOL. MAG. *Vol. IV. p. 185.*

This and *Scalaria Dupiniana* are the most characteristic and easily recognized of the Cretaceous Scalariæ. It was first described and figured by Michelin as *Melanopsis Clementina* in 1833; redescribed by d'Orbigny as *Scalaria*, and figured in the Pal. Franç., 1842; figured by Chenu in the Man. de Conchyliologie, and by Pict. & Camp., Terr. Crét. The species is very distinct, and there are fortunately no synonyms. It is mentioned by many authors from numerous localities in France and Switzerland, etc., and it must be considered to have had a wide range.

I have had an opportunity of examining the original of d'Orbigny's figure in the Pal. Franç. at the Ecole des Mines, and find that the drawing represents the whorls more convex and inflated than they actually are, and the aperture is a restoration. Dr. Chenu's figure is copied from this engraving. Pictet's figure is more truthful, but is taken from a very indifferent specimen.

This species departs in its character perhaps more widely than any other, from the typical Scalariæ, and also presents a peculiar instance of the power of the animal to secrete the ornamentation of its shell becoming enfeebled with age.

This species is essentially characteristic of the Gault, and is found at Folkestone, Lyme Regis, etc. The figured specimens are in my collection.

Sc. Dupiniana, d'Orb. Gault. Plate IV. Figs. 5 and 6.

Shell elongated; angle 23° to 25°, with fifteen or more rounded and inflated whorls; ribs coarse, obtuse, fold-like, generally numbering about twelve, but on the last whorls of larger specimens as many as eighteen, though then less prominent, as if effaced by age. Striæ regular, or alternately preponderating, more or less deeply marked and very variable in number, there being from twenty to thirty on corresponding whorls of equal-sized specimens (Plate IV. Figs. 5*a*, 5*b*). The spiral keel appears on the last whorl, against which the ribbing abruptly terminates. This keel is represented in the spire by a smooth sutural region, which is, however, sometimes overlapped. The basal or columellar region is marked by concentric *striæ* and by lines of growth. The mouth appears to have been nearly round, and the lips not thickened; but a specimen with the aperture satisfactorily preserved is still a desideratum.

In its young state the shell presents a somewhat different aspect, and the first eight whorls, which may be considered apical, have but seven or eight ribs, which are very salient and sharply defined, and with smooth intervals; at least, the striæ can only be detected with the aid of a microscope (Plate IV. Fg. 6). The striæ appear on the anterior part of the eighth and extend over the whole of the succeeding whorls. The cast preserves the form of the ribs, but is otherwise smooth; the whorls appear very inflated and separated by very deep sutures.

This shell was first described and figured by d'Orbigny, 1842, in the Pal. Fr. Terr. Crét., vol. ii. p. 154, and again by Pict. & Roux, 1849. The original of d'Orbigny's figure is now in the Ecole des Mines; the mouth is very imperfect, and has evidently been restored in the drawing. It occurs constantly in lists of Gault fossils, and appears to have a wide range in France and Switzerland.

In England it is characteristic of the Gault and Upper Greensand, it being abundant both at Lyme Regis and Folkestone. Specimens are in the British Museum from Devizes, and a fine example of the young state of this shell, from Blackdown, is figured (Plate III. Fig. 15), whence, however, no full grown specimens have been obtained. No species of true Scalaria has hitherto been found in the Cambridgeshire district. Most of the Lower Greensand localities cited probably refer to other species. These are described further on. *Scala Shutanurensis*, Stoliczka, of the Pal. Indica, is probably this species, the only difference noticed being a supposed coarser striation. *Sc. ornata*, a Cretaceous form from South Africa, also cannot be distinguished from this.

This and the various allied species are eminently characteristic of the Cretaceous age, and would alone serve to determine rocks of this age in any part of Europe.

Sc. CANALICULATA. d'Orb. Neocomian. Plate III. Figs. 5, 6.

Shell elongated, angle 16°; whorls numerous, rounded and inflated; ribs seventeen, well defined and regular, salient and rounded, nearly parallel with the axis; striæ very fine and even, seen, when strongly magnified, to be crossed by fainter transverse lines (Plate III. Fig. 5*a*); sutures distinct and slightly keeled; the last whorl with the usual roll-like collar[1] round the umbilical region, which is more distinctly and deeply striated, and is also marked by lines of growth. What has the appearance of being the mouth is ovate and the lips thin. The cast is smooth, but with traces of the ribs preserved.

A second specimen has the whorls slightly more depressed than is represented in Fig. 5, has rather stronger ribs, fourteen in number, and is without striæ.

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[1] I use the term collar for the keel on the basal whorl, against which the ribs terminate.

It was first described by d'Orbigny in the Pal Franç. Terr. Crét. (p. 50, pl. 154, figs. 1 to 3). Although of much larger dimensions than the shell originally described by d'Orb., the spiral angle, the number and appearance of the ribs, and a slight depression under the basal keel, named by him the canal, are points of resemblance that cannot be mistaken.

The specimen figured and the other above referred to are from the Cracker rocks of Atherfield, Isle of Wight, and are in the Geological Museum, Jermyn Street. The smaller specimen, Fig. 6, was found by Mr. Meÿer at the base of the Folkestone beds, Shanklin.

Sc. ISCHYRA[1], J. S. G. Lower Greensand. Plate III. Fig. 7.

Shell elongated, angle about 24°; whorls numerous, irregularly inflated, those near the apex being most elongated; ribs twelve or thirteen, rounded, coarse, irregular, sometimes nodose and flexuous; striæ raised and very even, with the intervals distinctly transversely ribbed; sutures distinct and keeled, the keel becoming visible as usual upon the last whorl in the form of a rounded collar; columellar region marked with numerous lines of growth; mouth ovate. Cast smooth with slightly marked ribs.

From the Lower Greensand of Shanklin, described from an unique specimen in the British Museum.

Sc. CRUCIANA,[2] Pict. & Camp. Neocomian. Plate III. Figs. 8, 9.

Shell elongated, angle 18°, whorls inflated and rounded; ribs twelve to fourteen, oblique, obtuse, extending to the sutures, more salient and fewer on the smaller whorls; striæ numerous and fine; sutures distinct; last whorl keeled, basal region smooth; mouth ovate.

Figured and described by Pict. & Camp., Terr. Crét. de Ste.-Croix. pl. lxxii. figs. 8, 9. The umbilical region, as described by them, p. 329, appears to be strongly striated, and to be marked with lines of growth; the smoothness of our specimens may, however, be the result of less perfect preservation. The ribs are also slightly more oblique than is represented by Pictet and Campiche.

The specimens figured are from the collection of Mr. Meÿer, and were obtained by him in the Lower Greensand of East Shalford.

Sc. FITTONI, J. S. G. Upper Greensand, Blackdown.
Plate III. Figs. 10, 11.

Shell elongated, angle 20° to 26°; whorls seven to nine, more or less inflated; ribs twelve to fourteen, rather coarse, prominent and rounded; staiæ numerous, regular, well defined, with narrow intervals (Figs. 10*a*, 10*c*) sometimes alternately preponderating (Fig. 10*b*); mouth ovate or rounded. The last whorl is keeled, but not so strongly as in the other species now described; the keel is crossed by the ribs near the columella; the basal region is strongly striated.

This is the most abundant of the Scalariæ met with at Blackdown, and I have therefore been able to examine a rather large series of pecimens, and have arrived at the conclusion that notwithstanding he varying convexity of the whorls and number of ribs in different hells, all the more coarsely-ribbed and striated forms met with in hese rocks are referable to a single species which has hitherto been onfounded with *Sc. Dupiniana.* It may, however, readily be disinguished by its lesser angle and higher whorls, by the closer rrangement of the ribs, finer striæ, and striated apical whorls. It s a much smaller and more delicate shell.

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[1] *ἰσχύρος, strong.*

[2] Ste.-Croix, Sancta Crucis.

The original from which Fig. 10 is taken is in the British Museum, nd Fig. 11 in the Museum of the Geological Survey, Jermyn Street.

Sc. CLIMASPIRA,[1] J. S. G. Upper Greensand, Blackdown.
Plate III. Figs. 12 and 13.

Shell elongated and very delicately tapering, angle 25°; whorls leven, convex and inflated; ribs fifteen, very narrow, salient and harply defined; striæ numerous, fine, distinct (Fig. 12*a*). The last vhorl possesses a spiral keel, the basal region is well marked, being pparently thickened over and filling in the ribs, and is beautifully eticulated by transverse and spiral lines. The principal transverse ines are coincident with the ribs; the thickening of the basal region nust have occurred after the ribs were formed, obliterating them nd leaving only indications of the lines of growth visible. Aperture rounded.

This is the most beautiful and delicate of all the fossil Cretaceous Scalariæ. The number and sharpness of the ribs and convexity of the whorls are its distinguishing characters. Fig. 12 was formerly in the collection of Dr. Bowerbank, and is now in the British Museum. Fig. 13 is in the Bristol Museum.

Sc. PULCHRA, Sby. Upper Greensand, Blackdown. Pl. III. Fig. 14.

Shell very elongated and tapering; angle 12°; whorls twelve, moderately high and convex; ribs eleven, distinct, prominent, rounded; striæ very fine and regular; basal keel not very distinct, and crossed by the ribs; the umbilical region is thickened and somewhat raised, in the manner described in the last species. Mouth pear-shaped.

This shell is briefly described and figured by Sowerby in the Trans. Geol. Soc. vol. x. 2nd ser. p. 343, and is not unlike *Sc. gracilis*, recent, but it also bears a strong resemblance to some of the *Chemnitziæ*, especially in the form of the mouth. It is the most slender of all the Cretaceous *Scalidæ.* The crossing of the basal keel by the ribs is also an interesting feature.

The original specimen I believe to be unique, and I am indebted to the kindness of Mr. Tawney, F.G.S., of the Bristol Museum, for the opportunity of examining it.

Sc. CERITHIOIDES, J. S. G. Lower Greensand. Pl. III. Fig. 16.

Shell elongated, angle 21°; whorls numerous, inflated, depressed, but becoming more elevated near the apex; ribs thirteen or fourteen, prominent, blunt and irregular, intercostal spaces ill-defined; striæ few, coarse, unevenly distributed and crossing the ribs, most pronounced near the sutures; last whorl keeled, possessing a comparatively smooth umbilical area, marked only by six or seven faint striæ and still less visible lines of growth; mouth obliquely ovate, rather angulated, lips not visible in any specimen yet met with, probably thin.

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[1] κλῖμαξ, a ladder.

This unique shell was found by Mr. Meÿer at the base of the Folkestone beds, Shanklin.

Sc. KALOSPIRA, J. S. G. Lower Greensand. Plate III. Fig. 17.

Shell very elongated, angle about 12°; whorls numerous, elevated, inflated; ribs ten, irregular, coarse and prominent, less distinct near the sutures; intervals ill-defined; striæ few and coarse, not more than seven; last whorl resembling that of *Sc. cerithioides* just described.

The ornamentation of this and the preceding specimen is strikingly similar, and it is possible that the discovery of a greater number and more perfect specimens may link them together. The spiral angle and elevation of the whorls at present serve to distinguish them. Both species bear a superficial resemblance to some of the Tertiary Cerithia.

The following species are cancellated and may be classed in Seeley's sub-genus

FUNIS.

The genus *Funis* was based by Seeley upon a not uncommon turreted shell, from the Gault of Cambridge, with elongated and cancellated whorls, and was thus described by him in the Annals and Mag. of Nat. Hist., 3rd series, April, 1861, vol. vii. pl. 11, p. 285:

"Shell thin, spiral, many-whorled, elongated. Columella straight, scarcely thicker than the shell of the whorls. Edge of the columella inflected and sharp; base truncated as in *Achatina*. Mouth ovate [shell cancellated ?]. Columellar lip reflected." To this description may be added:—lips thin, without trace of thickened peristome; whorls inflated; ornamented with transverse laminar ribbings and with spiral striæ producing a cancellated surface; no basal keel to last whorl.

There are a number of Tertiary and recent cancellated *Scalidæ*, but all possessing the broadened peristome. Several genera have been created to receive them.

The only generic characters on which *Funis* can now be recognized as a distinct genus are the thin shell, inflated whorls, cancellated surface, *combined with thin lips;* but the admission of the latter character as of generic value would render it necessary to create new genera to receiven early the whole of the Cretaceous *Scalidæ*, a step that we are hardly prepared to take, and the advisability of which would be open, in the present state of our knowledge, to much doubt. As more Cretaceous forms, however, come to light, I have no hesitation in saying that *Funis* will prove a useful generic name, and should therefore be retained.

Seeley has described two species from the Cambridge Gault or eensand: *F. elongatus*, pl. xi. fig. 7, and ? *F. brevis*, pl. xi. fig. 8, the volume above referred to.

The latter shell is in all probability a variety, and might be omitted m future lists of fossils. No species have hitherto been added, r have I seen any fossils described under other names which can referred to this genus.

FUNIS CREBRICOSTATUS, J. S. G. Upper Chalk, Norfolk.
Plate III. Fig. 18.

Shell elongated, angle 25°; whorls inflated and rounded; ribs merous, probably twenty to twenty-five, very thin and salient; ise exceedingly strong and prominent, about one-third closer to-her than are the ribs, which they cross, forming nodes at the ersections; sutures indistinct. The height and prominence of the ise, which is nearly as great as that of the ribs, give the shell a iculated appearance, whilst the nodes at the frequent intersections e it a rugose aspect. There are very faint traces of ornamentation served on the cast.

The fragment figured is in my collection.

FUNIS CANCELLATUS, J. S. G. Gault. Plate IV. Fig. 7.

Shell turreted, thin, angle 23°; whorls numerous, very inflated, th eight spiral ridges visible on each, except the last, which pos-ses twelve. The spiral ridges are crossed by finer transverse ribs, ich cancellate the surface, leaving a slight flattened node at each ersection. The transverse ribs and the nodes decrease in strength the whorls enlarge.

This shell I at first thought might prove to be *F. brevis*, Seeley; t a comparison has shown them to be quite unlike, the ornament-on being finer and far more regular. It is not unlike *Cerithium llierianum*, so much so, that there is a specimen placed with that ecies in d'Orbigny's collection, which is undoubtedly a *Funis*, and bably the one now described.

The specimen described is from the Gault of Folkestone, and is my collection.

We now come to a small group of shells which evidently cannot placed in the genus Scalaria, but which falls naturally into a genus stituted by Philippi under the name of *Pyrgiscus*, since united with *emnitzia*, d'Orb., and described as *Turbonilla* by Price & Adams. it the *Chemnitziæ* are placed in the *Pyramidellidæ*, a family into ich the present group cannot be received on account of its want of lumellar plaits, and it therefore becomes necessary to re-separate em and restore *Pyrgiscus* as a generic term. The resemblance of *rgiscus* to the forms of Scalaria just described is so great as to bid, in my opinion, the possibility of placing them in a family far moved, and I therefore think we are justified in following Deshayes' ample, and placing *Pyrgiscus* as a genus of the family of *Scalidæ*; ithout, however, following him to his ably argued conclusions against the subdivision of the family of *Turritellidæ*. Briefly stated, the argument is, that because there are transitional forms in the older Tertiaries between the *Scalidæ* and *Turritellidæ*, and also in the recent genus *Eglisia*, the families cannot be divided; but most conchologists would place *Eglisia* with the *Scalidæ*, and not, as Adams does, in the *Turritellidæ*; and the remainder of the argument, if carried to its logical conclusion, and if it were adopted by workers in the older rocks, would lead to the re-union of nearly all the families of Gasteropoda.

It must not be forgotten, and it is evident that, to admit the new group, the description of *Scalidæ* must be slightly modified; the essential character of the orbicular or ovate mouth with continuous border, however, remains.

PYRGISCUS, Philippi.

Shell elongated, many-whorled, ribbed; aperture oblong or ovate, peristome incomplete; columella straight, simple, without plaits or teeth.

PYRGISCUS GAULTINUS, J. S. G. Gault, Folkestone.
Plate IV. Figs. 8, 9, 10.

Shell elongated, thick, angle about 20°; whorls ten, flattened, apex rather obtuse (Plate IV. Fig. 9*a*), with slightly ventricose whorls; ribs ten to twelve, straight, rounded, prominent, extending quite to the sutures; striæ fine and regular, seen under a lens to be crossed by transverse lines (Fig. 9*b*); sutures distinct. Mouth rounded, a little angular and somewhat produced in front; columella straight; no keel on the last whorl.

This shell, which has hitherto escaped notice, or been considered as the young state, or a variety of *Sc. Clementina* or *Dupiniana*, is not uncommon, and may readily be distinguished from others of the Gault by its flattened whorls and obtuse appearance. The large specimen figured is from the collection of Mr. Craven, and is a magnificent example, and of most unusual dimensions; the smaller figures are from fossils in my collection.

PYRGISCUS WOODWARDII, J. S. G. Upper Greensand. Blackdown.
Plate III. Fig. 19.

Shell elongated, angle 18°; whorls numerous, flattened; ribs fifteen, angular, prominent and slightly bowed, extending quite to the sutures; striæ fine and indistinct; mouth pyriform or sub-quadrate; lips thin. The ribs on the last whorl are not very regular, and become attenuated near the columella; there is no spiral keel.

Described from an unique specimen, lately in Dr. Bowerbank's collection, now in the British Museum. I have named it after the Editor of this MAGAZINE, to whose courtesy I am indebted for frequent opportunities of examining the extensive collections not exposed at the British Museum.

PYRGISCUS TENUISTRIATUS, Seeley.

Described as *Cerithium tenuistriatum* in the Annals and Mag. of

Nat. Hist. for 1861, vol. vii. pl. 11, fig. 6. The form of the aperture and ribbed ornamentation leave no doubt as to its proper position being in this group. It is stated to be very rare, and from the Upper Greensand of Cambridge.

List of British Fossil Scalidæ.

	Lower Greensand.	Gault.	Upper Greensand.	Upper Chalk.
Group I.—Scalaria *Queenii*, J. S. G.			x	
,, *Meÿeri*, J. S. G.	x			
,, *compacta*, Sby.				x
Group II.—Scalaria *alba-cretæ*, Tate				x
,, *Clementina*, Mich.		x		
,, *Dupiniana*, d'Orb.		x	x	
,, *canaliculata*, d'Orb.	x			
,, *ischyra*, J. S. G.	x			
,, *Cruciana*, P. & C.	x			
,, *Fittoni*, J. S. G.			x	
,, *climaspira*, J. S. G.			x	
,, *pulchra*, Sby.			x	
,, *cerithioides*, J. S. G.	x			
,, *kalospira*, J. S. G.	x			
,, *elongatus*, Seeley		x	?	
Funis *crebricostatus*, J. S. G.				x
,, *cancellatus*, J. S. G.		x		
Pyrgiscus *Gaultinus*, J. S. G.		x		
,, *Woodwardii*, J. S. G.			x	
,, *tenuistriatus*, Seeley		x	?	

EXPLANATION OF PLATE III.

Fig. 1, 2.—*Scalaria Queenii*, J. S. G.; U. G. S., Blackdown. British Museum.
,, 1*a*.—Same enlarged twice.
,, 3, 3*a*.—id. 2 views, natural size. Meyer.
,, 4.—*Sc. Meÿeri*, J. S. G.; L. G. S.
,, 4*a*.—id. Another specimen enlarged to show ornamentation.
,, 5.—*Sc. canaliculata*, d'Orb.; Neocomian. Jermyn Street.
,, 5*a*.—Portion enlarged.
,, 6.—Small specimen of same. Meyer.
,, 7.—*Sc. ischyra*, J. S. G.; L. G. S. British Museum.
,, 7*a*.—Same enlarged.
,, 8, 9.—*Sc. Cruciana*, P. & C.; Neocomian. Meyer.
,, 10.—*Sc. Fittoni*, J. S. G.; U. G. S., Blackdown. British Museum.
,, 11.—id. Jermyn Street.
,, 10*a*, 10*b*, 10*c*.—Same enlarged.
,, 12.—*Sc. climaspira*; U. G. S., Blackdown. British Museum.
,, 13.—id. Bristol Museum.
,, 12*a*.—id. Enlarged.
,, 14.—*Sc. pulchra*, Sby.; U. G. S., Blackdown. Bristol Museum.
,, 15.—*Sc. Dupiniana*, d'Orb.; Blackdown. British Museum.
,, 16.—*Sc. cerithioides*, J. S. G.; Neocomian. Meyer.
,, 17.—*Sc. kalospira*, J. S. G.; Neocomian. Meyer.
,, 18.—*Funis crebricostatus*, J. S. G.; Upper Chalk. Author.
,, 19.—*Pyrgiscus Woodwardii*, J. S. G.; U. G. S., Blackdown. British Museum.

EXPLANATION OF PLATE IV.

Fig. 1, 2, 3, 4.—*Scalaria Clementina*, Mich.; Gault. Author.
,, 1*a*.—id. Enlarged.
,, 5, 6.—*Sc. Dupiniana*, D'Orb.; Gault. Author.

Fig. 6*a*.—id. Enlarged.
„ 7.—*Funis cancellatus*, J. S. G.; Gault. Author.
„ 7*a*, 7*b*.—id. Enlarged.
„ 8.—*Pyrgiscus Gaultinus*, J. S. G.; Gault. Craven.
„ 9, 10.—id. Gault. Author.
„ 9*a*.—Apex enlarged.
„ 9*b*.—Ornamentation enlarged.
„ 11, 11*a*.—*Brachystoma angularis*, Seeley; Gault. Author.
„ 12, 13, 13*a*.—*Rissoina incerta*, d'Orb.
„ 14, 14*a*, 15.— *Rissoina Sowerbii*, J. S. G.

(To be concluded in our next Number.)

III.—On the Classification and Nomenclature of Rocks.

By G. H. Kinahan, M.R.I.A., etc.

In a paper on the above subject, that appeared in the Geological Magazine for December, 1875 (p. 583), the author, Mr. S. Allport, F.G.S., objects to the introduction of additional rock names. With this observer I agree that there are many ingenite rock names which it would be satisfactory to get rid of; seeing many varieties and sub-varieties of rocks to which names are given have no permanent characters; while in numerous cases the same rock is called by different names. Still, as a geologist, I would suggest, that in some cases new names are absolutely necessary, if we would impart our increasing knowledge to the general public; for instance, among the granitic rocks, the subject that has led to Mr. Allport's remarks.

The granitic rocks at the present time are in a state of confusion. Among the newer granitic rocks, some are called granites, while others have been classed among the volcanic rocks; besides, some eminent geologists seem to be of opinion that all granites are of metamorphic origin, while others suspect they are all intrusive.

This state of things will continue until these rocks are grouped, not only in accordance with their origin, but also in relation to their geological ages. To do this some new names will be necessary; and if such names were generally adopted, any one reading a description of a country or district would be at once aware what was the age and origin of the different rocks. For instance, if Nevadite was the universal name for the elvanites, or passage rocks between trachytes and normal granite, it would save a great deal of repetition while describing many igneous districts. Similarly with granites of metamorphic and intrusive origin: if they had distinctive names, and were coloured differently on the geological maps, there would not be the confusion that at present exists.

On the Geological Maps of the Geological Survey Prof. Ramsay has introduced distinctive colours respectively for the bedded and intrusive igneous rocks, so that now the maps tell their own tale; and the granitic rocks might be treated similarly.

As I have pointed out in another place (Handy Book of Rock Names), a reform is very necessary in rock nomenclature. This, however, cannot be effected by one individual unless he be a perfect field geologist, mineralogist, chemist, and microscopist. To me, therefore, it appears that it ought to be done by a committee selected from persons eninent in these different pursuits. The classification proposed by Mr. Allport might do for Lithologists; but it would not do for Petrologists, as the latter find in the field that siliceous rocks graduate into basic; also that nearly invariably some portions of a dyke or felsite will be porphyritic; while it is rare to find a felsite that is not quartzose; in some the quartz being more conspicuous than in others.[1]

Mr. Allport states that he has "shown elsewhere that basic rocks of widely separate geological periods are identical in composition and structure." This may be, to his own satisfaction, but not to that of all chemists and microscopists; as Forbes and others seem to be of the opinion that this statement is *not proven*, and that the basic rocks of the widely separate geological periods contain different felspars. For my own part, in the field, I find that, after a perfect knowledge of the rocks is acquired, it is generally possible to say to what geological age the different rocks belong. This observer also gives what he considers two fallacies underlying the present system of classification:—"1st, that plutonic rocks have not been formed in connexion with true volcanos; and, 2nd, that rocks of different geological ages are characterized by a difference in mineral constitutions." Of the second it is only necessary to point out, that up to the present time, it does not seem to have been proved to be a fallacy. The first is a fallacy in a certain sense, in others it is not. The terms Volcanic and Plutonic have been used loosely, similarly to all other rock names. Strictly speaking, volcanic rocks are those formed at the surface, while plutonic rocks were formed below the surface, and the granitic rocks at still greater depths; therefore all volcanic rocks *must have been formed in connexion* with plutonic and granitic rocks. But it does not necessarily follow that all granitic and plutonic rocks must have been formed in connexion with volcanic rocks; and many of the older igneous rocks were irrupted under quite different circumstances from those under which volcanic rocks were and are erupted.

As pointed out by Le Conte and others, a volcano is a mere flyblow on the earth's surface, due to the dying out efforts of Vulcanicity, and made up of scoria and the like, traversed by dykes and associated with lava-streams that sometimes form small sheets. The older igneous rocks sometimes seem to be the remains of ancient volcanos; but more generally they are the products of great fissure irruptions, which ejected vast quantities of molten and other matter, which now form extensive sheets. This is exemplified by the Irish rocks. In the province of Ulster during the Miocene (?) period, there were large successive outpourings of igneous rocks, that covered miles of country with sheet after sheet of rocks; while subsequently the vulcanicity seems to have died out in volcanos at isolated localities.—In the Carboniferous Limestone of the central plain (Leinster and Munster) there seem to be the remains of volcanos. Even the circles of igneous rocks and their accompanying agglomerates and tuffs that surround the Coal-measures of Ballybroad, co. Limerick, possibly may mark the site of an ancient volcano, as they do not exceed in dimensions some of the craters recently described in the GEOL. MAG. by Mr. Judd. But in the Carboniferous slates of the co. Cork, and the Devonian rocks near Killarney, as pointed out years ago by my colleagues G. V. du Noyer, M.R.I.A., J. O'Kelly, M.R.I.A., and myself, there were fissure-irruptions; although in one place, Blackballhead, there are the remains of an ancient volcano.—In the rocks of Cambro-Silurian and Silurian age, in the counties of Mayo and Galway, also in those of Cambro-Silurian age in the cos. Wicklow, Wexford, and Waterford, there are vast sheets of igneous rocks, quite different from any now due to volcanos. It is therefore evident that most of the Irish igneous rocks, even those of Tertiary age, were irrupted under different circumstances from those accompanying the eruption of lavas; and although a better classification of the rocks than that at present in use (Volcanic and Plutonic) might be adopted, yet it would be incorrect to call them all volcanic.

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[1] Mr. Allport objects to the term elvanite because it has been misused. On the some principle nearly all the rock names ought to be rejected; especially granite, as the latter is a common name in many places for hard and coarse sandstones.

In some place or another there are igneous rocks of the same respective ages as the different geological groups, and each of these groups of igneous rocks must have had their granites, although in many cases they may not be now exposed by denudation. But it seems extremely questionable that "the old felstones and porphyries were originally identical with the more recent trachytes." The old felstones and porphyries, as shown by Jukes, are in most cases the roots or deep seated accompaniments of vulcanicity; and if volcanos existed in connexion, they were subsequently removed and the material scattered by denudation; while the more recent trachytes are normal volcanic products.

Mr. Judd, in his recent paper on the igneous rocks of the Hebrides (quoted by Mr. Allport), shows (similarly as was proved in other localities twenty years ago by Haughton) that the surface or volcanic siliceous rocks, in depth, pass into granite; he also mentions, that the dolerites, in depth, pass into coarsely crystalline gabbros. This leads us to the consideration of the passage of basic igneous rocks into normal granite.

In Yarconnaught or West Galway there are igneous rocks (gabbro or diabase) that, as pointed out in the Memoirs of the Irish branch of the Geological Survey, and elsewhere, when affected by metamorphism, are changed into the rock called by Macculloch hornblende rock; diorite (amphibole + triclinic felspar); syenite (amphibole + orthoclase); and rocks that, in addition to amphibole, may contain both orthoclase and triclinic felspar. These rocks, as the metamorphism becomes more intense, become granitic, till eventually they change into hornblendic granite. Similarly with the non-metamorphic rocks, Judd points out that the dolerites of the Hebrides, in depth, pass into coarsely crystalline gabbros; for the latter rocks others have proposed the name of granitone; as the rock, although *granitoid,* was not considered a normal granite. If, however, we take a wide and scientific meaning for granite—such as that in part adopted by Macculloch—these rocks should be included among the granitic rocks; or at least considered passage rocks between the basic and granitic rocks. Such rocks, as far as my experience goes, always contain more or less mica and quartz, and when they are capable of being examined in depth, the pyroxenic minerals are found to be gradually replaced by amphibolic; and such a rock, consisting of a crystalline aggregate of felspar, amphibole, mica and quartz, must be called a hornblendic granite. This seems to be the case in the country around Carlingford (referred to in my former communication), as the Slieve Fag rock (which in places might be called a coarse gabbro, in others a hyperite) seems to graduate into a hornblendic elvanite.

In the field a twofold division of the igneous rocks into highly siliceous and basic, is found very unsatisfactory. There are certain rocks called *Eurytes* by Daubuisson, *Hybrid rocks* by Durocher, also including the *Trachydolerites* of Abich, that partake of the nature of both the felstones and whinstones. Such rocks often occur as bedded sheets, parts of a bed being a rock that must be called a felstone, while other portions are a rock that must be called dolerite, or some other variety of whinstone; or, as is often the case, the lower portion of the bed will be more felspathic than the upper; but in either case, whether the change is vertical or horizontal, one kind of rock graduates imperceptibly into the other, so that it is impossible to draw hard boundaries between them. On the Government maps in these cases, of late, the colour for the siliceous is blended into that for the basic rocks. If, however, such rocks were in a separate group, and had a colour for themselves, the work would be more complete.

In reference to *bottleite*, Mr. Allport places it in his "acidic group," and says the name is "synonymous with trachalite." The rock trachalite I do not know, but I find that in 1826 Breithaupt described a rock which he called "Tachylyte" (ταχυς λυτος), which seems to be the same as the County Down *bottleite*. In that county this rock, in places, margins and graduates into dykes of dolerite, and apparently belongs to the basic group of the igneous rocks.

IV.—NOTE ON AN ANNELID BED IN THE GAULT OF KENT.

By Prof. T. RUPERT JONES, F.R.S., etc.

THERE is a peculiar band, full of Annelid borings, in the Gault of Kent, which does not appear to have been recorded in the papers on the Gault of Folkestone, by Mr. De Rance, in the GEOL. MAG. 1868, Vol. V. p. 170, etc., and Mr. Price, Quart. Journ. Geol. Soc. 1874, vol. xxx. p. 344, etc. It may possibly, however, be one of the "hard bands" noticed in their sections, but not described in detail. In 1866 I collected some specimens of this Annelid Bed in a Gault pit, dug for brick- and tile-making, at Westwell Leacon, a mile and a half S.W. of Charing, Kent. It was about two inches thick, continuous across the pit, red in colour, with bluish pipings throughout in every direction; it was much harder than the blue clay above and below, and relatively heavy. There seemed to be only one band of it; and its fragments were picked out and thrown aside by the clay-diggers, who called it "Harper."

This has been brought to my remembrance more especially by the following extract from Prof. Wyville Thomson's Report of the *Challenger* Expedition, read before the Royal Society, November 18, 1875 (see Proceed. Roy. Soc. vol. xxiv. p. 33; and *Nature*, vol. xiii. p. 70, November 25, 1875):—"On the 17th of June we sounded in 1875 fathoms, with a bottom of bluish-grey clay and a bottom temperature of 1°·7 C., forty miles to the S.E. of No-Sima Lighthouse (Japan). The trawl was put over, and it brought up a large quantity of the bottom, which showed the clay was in a peculiar concretionary state, run together into coherent lumps, which were bored in all directions by an Annelid of the Aphroditacean group. In many cases the Annelids were still in the burrows."

The analogy of hardened clay, bored by Annelids, in deep-sea clay, with the Annelid band of the Gault above mentioned, is sufficiently striking to be noticed, although the clays and the Annelids referred to probably differ, respectively, in several characters, and the depths of the two seas were also greatly different. The modern deposit, however, may throw light on the history of part, at least, of the old Aptian formation.

I believe the "Harper" to lie in the upper portion of the lowest third of the Gault,[1] which is here very rich with Foraminifera and Entomostraca. These are ignored in Messrs. De Rance and Price's lists of Gault Fossils; but they have had justice shown to them in Mr. Topley's Table IV. Appendix I., "Memoirs Geol. Survey, Geology of the Weald," 1875, pp. 423-426. The old clay-pits of the Westwell Leacon yielded several of the fossils enumerated in Dr. Fitton's "Strata below the Chalk," Geol. Trans. ser. 2, vol. iv. pp. 112, 113.

I may add that, from a comparison with the Microzoa brought up from known depths in the present seas, the Foraminifera of the Gault (like those of the London Clay) seem to my friend Prof. W. K. Parker, F.R.S., to indicate a depth of about 100 fathoms.

V.—SKETCH OF THE GEOLOGY OF ICE SOUND AND BELL SOUND, SPITZBERGEN.

By Professor A. E. NORDENSKIÖLD, of Stockholm;
For. Corr. Geol. Soc. Lond.

PART III.

(*Continued from the February Number, page 75.*)

VI. *Jura.*—In all probability the strata which form the summit of the mountain north of Reindeer Valley in Saurie Hook belong to the Jurassic formation, which besides occupies a considerable extent on Spitzbergen, from the entrance of Ice Sound to Cape Agardh in r Fiord. To judge from the beds at the latter place, the only that I know of which affords a comprehensive section of the erent strata belonging to this formation, the Jurassic strata of tzbergen consist of—

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[1] The junction of the Lower Greensand with the Gault used to be well seen in a sand-pit at the southern limit of the Leacon Common (now inclosed), about a quarter of a mile S.E. of the brickyard above alluded to.

L. *Marine Strata.*—1. (Lowermost) Clay-slate, very rich in pyrites, consequence of which the Belemnites (of the group *Arcuati*) edded in large quantities in these slates are much incrusted.

. Limestone containing iron, yellow after exposure to the air, i in badly-preserved fossils.

. *Consisting of a hard, nearly unfossiliferous sandstone, devoid marine organisms, but* (at Cape Boheman) *containing Coal-beds slates with impressions of plants.*

itrata belonging to the first division A. of the Jurassic formation ur in Ice Sound at the following places:—

. *Cape Staratschin.*—The rocks along the shore, immediately west the "sandstone comb." Black slates (1) standing vertically in some places much contorted. They are divided by the ndstone comb" (2) from the stratum containing Cretaceous fossil nts at (3); and which about 4000 feet nearer the mouth of the

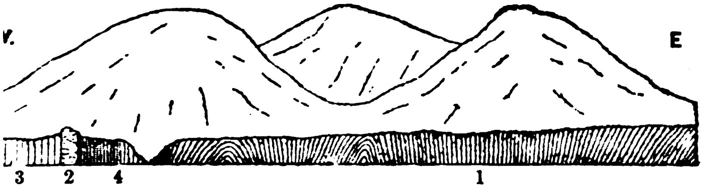

FIG. 10.—Shore rocks on the southern side of the entrance to Ice Sound.

und, without any proper oryctognostic boundary, pass into Triassic ata at (4). If we follow the shore further outwards, we find first sandstone, probably belonging to the Carboniferous formation, t a Mountain Limestone stratum, of which also the high ridge formed, and finally strata belonging to the Hecla Hook formation. rcely 2000 paces inwards again we have the richest locality Spitzbergen for varieties of Miocene plant-remains. The strata onging to the later formations are clearly hereabouts more ongly dislocated than the Palæozoic beds, which lie nearest them, emarkable circumstance, the cause of which I shall attempt to te further on. It was here that the Jurassic formation of Spitzrgen was first discovered by Lovén in 1837, and some few metres nce the Chalk stratum by me in 1872. The division B of the rassic formation is evidently absent at this place.

b. *Green Harbour.*—In the region of this fiord the Jurassic strata p out at several places, though, in consequence of their poverty fossils, they can seldom be recognized with certainty. We have opportunity of examining a section of the strata at the banks of a er, which falls into the sea on the west side near the entrance of een Harbour. Here, too, the strata stand nearly vertically, strike and S., and consist of clay-slates, alternating with a grey limene, containing ill-preserved Belemnites and traces of bivalves.

c. Advent Bay.—The shore rocks here consist for the most part of an aluminous limestone, and a black slate containing Jurassic fossils, but only in limited number, and generally in a bad state of preservation. Among these fossils may be specially named a small fossil starfish (*sjöstjerna*), of which a couple of very beautiful specimens were obtained. The strata here lie horizontally, and evidently occupy a very large extent of country both towards Coal Bay and Sassen Bay.

d. Sassen Bay.—On the south shore close to the entrance of the fiord. The upper part of the mountain consists here probably of Miocene strata, the foot of Jurassic strata, which at the shore lie nearly horizontally, and consist of black slates and grey limestone, rich in ill-preserved fossils, among which Lindström names *Aucella Mosquensis*, *Cyprina inconspicua* and *Ammonites triplicatus*.

No sharp boundary between the two divisions into which, on the ground of observations at Cape Agardh, I have divided the Jurassic strata in Spitzbergen, can be observed at these places, inasmuch as the slates are often intersected by seams of limestone and infused with colossal *black* round nodules, which, however, are distinguishable from the nodules of the Triassic formation by their less regular form and darker colour.

These nodules occurring in the Jurassic strata (I.), and the Sphærosiderite from the second division at Agardh's mountain (II.), have been analyzed by Mr. G. Lindström, who found them to contain:

	I.		II.
Carbonate of lime	48·52	...	6·95
Carbonate of magnesia	2·32	...	15·36
Carbonate of protoxide of iron	4·48	...	51·30
Phosphate of lime	0·39	...	1·85
Sulphate of lime...	trace	...	0·22
Alumina	1·36	...	——
Oxide of iron and a little alumina	——	...	1·35
Chlorine	trace	...	trace
Incombustible residue insoluble in acids ...	39·81	...	21·07
Bituminous matter and moisture	3·12	...	1·90
	100·00		100·00

The fossils are ill preserved, broken and worn asunder, on which account their determination has been attended with many difficulties. Dr. Lindström, in his previously quoted work, enumerates the following species:

1. *Ammonites triplicatus*, Sow.
2. *Cyprina inconspicua*, Lindström
3. *Cardium concinnum*, v. Buch.
4. *Solenomya Torelli*, Lindström.
5. *Leda nuda*, Keys.
6. *Inoceramus revelatus*, Keys.
7. *Aucella Mosquensis*, v. Buch.
8. *Pecten demissus*, Beau.
9. *Pecten validus*, Lindström.
10. *Ophiura Gumælii*, Lindström.

In addition there is a number of species, not distinguishable with certainty, of Fishes, *Serpula*, *Belemnites*, *Dentalium*, *Panopœa*, *Tellina*, *Cytherea*, *Arca*, *Nucula*, *Avicula*, etc.

Of these fossils, 1, 3, 7, 8, occur at Moscow, principally in Trautschold's "Mittlere Etage;" 1, 3, 5, 6, in the Jurassic strata at Petschora.

The stratum A 2 is, if we except the Mytilus-stratum at Cape Thordsen and Advent Bay, *the latest stratum on Spitzbergen which contains marine fossils,*[1] and it is therefore supposed that the configuration of Spitzbergen underwent considerable changes during the Jurassic period, inasmuch as the sea which formerly covered these regions was exchanged for an extensive continent.

The uppermost stratum (B) of Agardh's mountain is separated by a thick seam of diabase from the underlying strata, and consists of a hard sandstone, in which I have not found any determinable fossils. In outward appearance this sandstone corresponds completely with the sandstone from Cape Boheman, in which Dr. Öberg and I, during the Expedition of 1872–73 found fossil plants, which, according to the determination of Oswald Heer, belong to the Jurassic period.[2] From this circumstance, and from the oryctognostic resemblance between the sandstone at Cape Boheman and the uppermost stratum of Agardh's mountain, it is perhaps probable that these strata occupy nearly the same geological position.

Cape Boheman is a low promontory, principally consisting of sandstone, which projects into Ice Sound from the middle of the north-west coast. South of its extreme point there are several small islands, which are yearly visited by the Spitzbergen whalers for the purpose of collecting eggs and down. As of late years small steamers have been employed in the fishery, these too are accustomed to visit the place to obtain a supply of coal from a seam which is found in the rock in the neighbourhood of the islands in the steep shore terrace which everywhere bounds the peninsula. The succession of strata here is shown in the profile below.

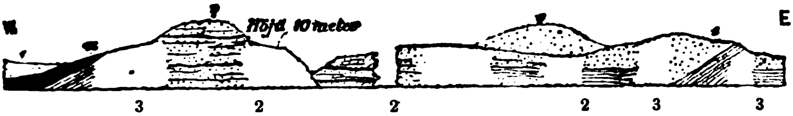

Fig. 11.—Section of Jurassic strata at Cape Boheman.
1. Sandstone. 2. Sandstone mixed with Coal and Shale. 3. Slates.

The principal mass of the strata consists of a hard, nearly unfossiliferous, mostly white sandstone, which at some places is mixed with clay, and thus passes into sandy clay-slate. Besides, the sandstone is many times intersected by thin coal-seams, and at *a* by one of considerable thickness. The succession of strata here is:

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[1] Some univalves and fragments of fossil wood found in the Tertiary strata at Cape Staratschin are described by Mayer in Oswald Heer's *Miocene Flora and Fauna von Spitsbergen*, and are considered, at least partly, to belong to marine types. The broken and fragmentary condition of these fossils and their occurrence, the vegetable fragments included, in a stratum, merely local, of one or two inches thick, imbedded among purely fresh-water forms, however, shows that they do not lie *in situ*, but have been washed out of some older marine stratum.

[2] Some ill-preserved vegetable impressions (pieces of Cycadea) were brought home from this locality during the Expedition of 1864, although they have not been subjected to a close examination. As at that time Miocene Coal-seams only were known to occur at Spitzbergen, I referred these strata in my sketch of the geology of Spitzbergen to the Tertiary period.

White sandstone (uppermost)	2·0	metres
Soft black sandstone mixed with coal	0·5	„
Good coal	0·1	„
Shale	0·1	„
Sandy shale with coal-seams	0·6	„
Pure coal	0·6	„
Shale	0·1	„
Good coal	0·3	„

The fossils, which exclusively consist of vegetable impressions, were found chiefly west of *a*, in a sandstone containing some iron, partly in the shales lying next the coal.

I do not know with certainty any other place where coal-seams and strata with vegetable impressions belonging to this division occur on Spitzbergen. It is, however, possible that the seam of coal referred to at greater length farther on, and a hard, fossiliferous sandstone, which are exposed on the steep slopes of the mountain ridge between Advent Bay and Coal Bay, belong to this period.

VII. *Diabase.*[1]—The eruptive rocks which overlie the marine Jurassic strata on Agardh's Mountain form the most recent of the plutonic formations which have been formed on Spitsbergen, and it cannot therefore be out of place here to describe with some minuteness this important member of the geological structure of the country. This rock was first discovered by the geologists who took part in the French Expedition in the frigate *La Récherche*, and who, after their return home, described it under the name of "*selagite ou siénite hypersthènique.*" A more complete account of its occurrence is given by me in my work on the geology of Spitzbergen, in which I have employed the word *hyperite* as synonymous with *selagite* for denoting this rock. Through Descloiseauz's remarkable examination of hypersthene, and the new methods of obtaining a knowledge of the component parts of rocks by microscopic examination of thin plates, it has appeared that a great many of the rocks which were thought to contain hypersthene contain instead some other variety of augite, and in this way many rocks which were formerly called hypersthenite do not contain the mineral from which they obtained their name. Among the number of these is the Spitzbergen hypersthenite, according to examinations made by Zirkel (Neues Jahrb. für Min. 1870, p. 808), Törnebohm (private communication), and others. The name by which the rock was formerly denoted must therefore be exchanged for another, and I shall in this case, following Zirkel's determination, employ the name *diabase,* although *dolerite* perhaps were a more correct designation for the eruptive rocks from these localities on Spitzbergen.

The Spitzbergen diabase consists of an equal-grained mixture of labradorite, a species of augite and titaniferous iron. It has, when freshly broken, a greyish-black or greenish-black colour, which often becomes dark brown through the action of the atmosphere. Under the microscope olivine (Törnebohm) and chlorite may be discovered as occasional ingredients. The latter mineral, however, is believed to be absent in the rock from a number of the localities, whereby it takes the nature of dolerite.

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[1] In my sketch of the geology of Spitzbergen I have noticed the plutonic rocks plentifully occurring in these regions under the name of hyperite. According to later microscopical examinations of the rock, this name ought to be exchanged for diabase.

The Spitzbergen diabase has been analyzed: (1) from the Goose Islands in Ice Sound by Mr. G. Lindström (paper previously quoted, page 671); (2) from Tschermaksberg by Professor Teclu (Min. Mitheilungen, 1874, h. iv. p. 263); (3) from Saurian Hook by Teclu (paper quoted, p. 264).[1]

The specific gravity of 2 and 3 is = 2·98.

	1.	2.	3.
Silica	49·78	51·17	50·96
Titanic acid	2·97	trace	trace
Lime	9·44	10·72	10·11
Magnesia	5·65	5·77	5·39
Alumina	14·05	14·29	5·23
Oxide of iron	14·86	17·87	27·78
Protoxide of manganese	·13	—	—
Potash	1·70	0·18	0·27
Soda		0·96	0·04
Loss	1·42	·90	·99
	100·00	100·86	100·77

This rock commonly occurs in strata which, with the same regularity as the sedimentary rocks and without branching out into side veins, form distinct links in the Mountain Limestone, the Triassic and Jurassic formations. Less frequently it occurs in isolated mountains, seldom in the form of veins. In numberless cases it occupies the slopes at the foot of the mountain where the black stone surfaces are like a parquet floor divided into chequers, corresponding to the sections of the pillars, into which the stratum is cleft, and at the same place the summit of the mountain is generally occupied by a horizontal, black or rust-brown diabase stratum, also cleft into basaltic pillars. As there are no cavities, the minerals with which these are commonly filled are also completely absent.[2]

With respect to the occurrence of the prismatic structure in basalt, I may be permitted to refer to my sketch of the Geology of Spitzbergen, p. 35, where it is stated that "No satisfactory explanation has hitherto been given of this remarkable phenomenon, which is

[1] In quoting these analyses von Drasche gives utterance to a doubt of the correctness of Lindström's determination of titanic acid in the addendum: "Wie leicht kann ein durch Fluss-säure noch nicht, ganz aufgeschlossener Theil des Silikates als Titansäure gewogen werden." This doubt is unwarranted, and perhaps shows why Teclu only found a trace of titanic acid. Small quantities of titanic acid are not obtained in the way stated by Herr von Drasche, because the acid passes into the solution. In the analysis made by Lindström at the laboratory for mineral analysis at the Riks Museum, the titanic acid was precipitated by boiling and the pecipitated acid was forced from iron by means of acetic acid and hydrosulphate of ammonia.

[2] Among the pebbles on the north-east side of North-East Land I found some pieces of Chalcedony, whose form clearly showed that they had been formed in cavities of basalt. This is considered to prove that such rocks occur on the groups of islands north-east of Spitzbergen. Perhaps it was in these regions that the eruptions took place from which the Spitzbergen diabase beds originated. According to Keilhau, pebbles with cavities also occur on Stansforeland.

especially peculiar to basalt, and which by some geologists has been regarded as a result of concretionary structure, or even compared to a kind of crystallization of the whole mass of the rock. The origin of the basaltic structure, however, appears to lie near at hand, and the phenomenon, though operating on a smaller scale, is a very common one. If, on a warm summer day, we walk across a bed of clay, the surface of which has become dry, we shall often see the crust of the clay broken into regular and mostly hexagonal figures. Fissures of the same form may be seen on the marshy plains which are met with at the foot of the mountains in all parts of Spitzbergen. In the middle of summer, when the snow has just melted, they are so very marshy, that in going over them one sinks to the knees in the moist, angular gravel, but towards autumn they generally become quite dry, and the surface splits into regular figures. *The gradual contraction of a solid mass* evidently constitutes the common cause of the hexagonal structure of these so widely different substances.

"When the clay or the gravel beds dry, or the plutonic rock cools, a contraction takes place, beginning at the surface, or at the walls of the vein, and gradually perpetuating itself to the interior, the result of which evidently is a bursting of the mass. Then the two following conditions *must* be fulfilled:

"1. The bursting must take place in such a manner that the resistance it meets with proves a minimum. 2. The particles must not be dislocated to so high a degree as to loosen the upper contracted bed from the lower one that is yet uncontracted. This latter condition is a necessary consequence of the contracting process beginning at a certain plane and perpetuating itself gradually to the interior of the mass.

"If we solve this minimum problem mathematically on the bases of the two conditions above stated, we find that the clefts which arise in a solid mass when it contracts must necessarily be composed of plane surfaces crossing each other so as to form regular hexagonal columns, and be perpendicular to the surface where the temperature is constant, or parallel with that direction in which the contraction is progressing. *The columnar structure peculiar to basalt is thus a simple consequence of the fact that the bursting, caused by the contraction of the solid mass in cooling, takes place along a system of surfaces where the resistance is at minimum;* and the basaltic structure *has nothing in common with the concretionary structure, or with crystallization: although the regular form of the basaltic columns gives them a certain resemblance to crystalline prisms.*"

On the west coast of Spitzbergen, where the strata are almost vertical, the diabase only sparingly occurs. It is likewise nearly absent on Liefde Bay and the north coast of North-East Land. On the contrary, it occurs well developed on the inner part of Ice Sound, Hinloopen Strait, and Stor Fiord.

I have had several opportunities of observing the contact between the diabase stratum and the underlying strata. The latter, if they were

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[1] The transverse clefts which often divide the basaltic columns seem to arise from an interruption in the successive contraction, caused, for instance, by infiltration of water in the solid but yet warm rock.

ginally formed of limestone, have then sometimes the appearance if they had been burnt, but on a closer examination it is found it the alteration arises from the limestone strata being impreg-ted with silica. The altered appearance of the stratum, therefore, ginates rather from an infiltration of silica than from the action of it. I consider it highly probable also that the immense flint atum—often containing shells of *Productus*, etc.—which occurs the Mountain Limestone formation, has the same origin as the base beds.

It is scarcely possible to consider these beds purely eruptive mations, though I by no means deny that the veins of diabase d probably also that which forms isolated rocks without ad-xture has broken out in a state of fusion from the interior of the th. It appears to me that the diabase strata can only be accounted by the supposition that they are composed of immense strata of lcanic sand and ashes, which in the lapse of time were meta-rphosed into a hard crystalline rock. It is possible, too, that gravel originating from the action of the atmosphere upon the base which has thus been formed, may, under favourable circum-nces, without intermixture of foreign matter, be collected into ata of diabase sand,[1] which sand, under circumstances favourable ereto, may again be compacted into a rock not distinguishable m that from which it originated.

A pseudo-plutonic stratum of this kind may therefore be inter-atified with fossiliferous beds, deposited much later than the terial of the pseudo-plutonic stratum was thrown up from the terior of the earth.[2]

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[1] Such strata of diabase sand also now occur in many places on the coasts of itzbergen; for example, in Hinloopen, off the Low Island, etc.

[2] I have before given expression to the view that the condition of a rock depends ich more on the composition of the original materials than on the mode of occur-ice, and that a volcanic glass and a sediment of the same chemical composition, er the lapse of immense periods of geological time, give the same ultimate oduct, inasmuch as the molecules arrange themselves according to the most vourable relation of equivalents; and as an instance showing that molecular inges may take place in solid substances, I may point to iodide of silver, to the inges produced in the form of sulphur crystals, and to iron which has been exposed a length of time to concussions (for instance, axles of railway waggons). I have tained besides two geological examples of such changes. The first I got from the tinguished chemist Gentele, who, without knowing that he was contributing to the ution of a disputed point of great importance in geology, some few years ago, sent the Riks Museum a box of common light grey malakolite, *on account of the extra-linary circumstance that the mineral when removed by blasting from the mountain s amorphous, but soon after began to assume a coarsely crystalline structure.* The ier was communicated to me by A. G. Nathorst, Docent in Geology at the Univer-y of Lund, whose attention, when he took part last summer in the geological rvey of Sweden, was directed by a farmer to a vein of calcspar which had *under-e a change of texture from a compact to a crystalline state during a period of* 25 *to years*. I have wished to quote these cases so much the more because there is possibility that the observers have been led astray by a theoretic view previously opted. Those who are disposed to deny the possibility of a mass of the nature of a being changed to a crystalline rock, ought besides to keep in view that, cording to all experience, a melted mass of silica cools *to a glass*, and that therefore r the purely eruptive diabase we also must suppose that an inward molecular change d take place after the solidification of the rock.

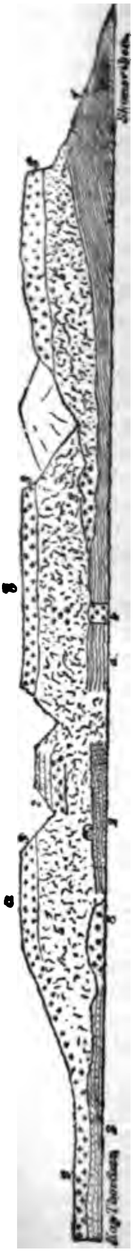

Fig. 12.—Profile of Strata between Cape Thordsen and Skansviken. 1. Bed of gypsum containing a few Mountain Limestone fossils. 2. Triassic strata. 3. Diabase, mostly stratified, but forming a vein at 4. 5. Mountain sides covered with gravel and angular diabase blocks.

In Ice and Bell Sounds diabase is found at the following places:

1. *Bell Sound.*—Right opposite Axel's Islands, on the north shore of von Mijen Bay. A stratum of considerable thickness in the Mountain Limestone formation occurring here.

Inner part of Recherche Bay.—On an isolated mountain, on which the French Expedition erected its observatory, hence called Observatory Mountain, delineated in the Atlas of the Expedition.

2. *Ice Sound.—The high ridge off Cape Staratschin.* Three thick strata, which are quite conformably interstratified with fossiliferous beds of Mountain Limestone.

The Entrance to Sassen Bay.—An isolated rocky hill of inconsiderable height on the south side of the entrance.

Gip's Hook.—A diabase stratum here forms the slopes at the foot of Gip's Hook.

The Goose Islands off. Gip's Hook.—Probably a continuation of the same stratum.

Cape Thordsen.—On this promontory the diabase occurs in many places, partly as rocky hills without admixture, partly as thick and parallel strata, and at some places also as true veins. The manner of its occurrence may be seen in the accompanying profile. (Fig. 12.)

Unfortunately the mountain sides in this profile are so covered up with gravel that I cannot make out with certainty whether the diabase on the mountains *a* and *b* only forms a stratum, or if it there takes up the whole mountain. At 3 the underlying slate beds are covered by a diabase stratum, which, however, is at most places so completely split up on the surface that it has been changed to a collection of stone heaps. At 4, in the neighbourhood of the sea-shore, there occurs a well-marked vein surrounded by its matrix. It here intersects, without in any great degree disturbing the lie of the neighbouring strata, several grey marl beds, probably belonging to the Mountain Limestone. The diabase occurs very beautifully stratified round Reindeer Valley, where it forms two regular strata, of which the one, with a thickness of about nine metres, at a height of about 200 to 300 metres, forms on the mountain a shelf, with precipitous sides; the other is formed in the same regular way, parallel with the former and several hundred feet higher. Von Drasche has given the following profile of the mountain, called by him Tschermak's Berg. By Blomstrand and myself it had formerly been called Middle Hook.

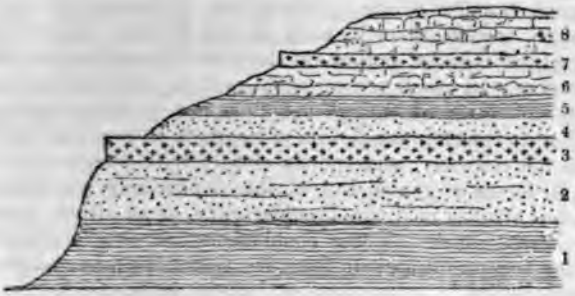

FIG. 13.—Profile of Tschermak's Berg, in Ice Sound, by von Drasche.

1. Black bituminous marl, with many coprolites, Cephalopoda, and bivalves. 2. Reddish sandstone, with but few fossils. 3. Diabase. 4. Reddish sandstone, like 2. 5. Clay-slate. 6. Limestone, with very evident traces of the action of waves. 7. Thin stratum of diabase. 8. Grey limestone.

Ekman Bay.—The bottom of the fiord is occupied by a glacier, off which the fiord is for a considerable distance so shallow that a boat cannot be rowed in it. The sides are formed of two mountains, which in an architectural respect are the finest I know of on Spitzbergen, and which on that account were by us distinguished with the names Colosseum and Capitolium. The geological structure of both is clearly identical; they consist of horizontal Mountain Limestone strata, succeeded by a bed of gypsum marl, divided with the utmost regularity into niches and beautiful rows of pillars, on which rests a roof of diabase, which, however, does not here form the terrace with precipitous sides at the summit of the mountain. The Mountain Limestone strata further up the fiord rest (as seen in the profile Fig. 7, given in the last Number of the GEOL. MAG., at p. 68) on the Liefde Bay strata.

(To be continued in our next Number.)

NOTICES OF MEMOIRS.

REMARKS ON THE ORGANIZATION AND SYSTEMATIC POSITION OF RECEPTACULITES. By C. W. GÜMBEL. [BEITRÄGE ZUR KENNTNISS DER ORGANISATION, u. s. w.] From the Transactions of the Royal Bavarian Academy of Sciences, Math.-Phys. Class. Vol. XII. Part I. 4to. 49 pages, 1 plate. Munich, 1875.

VARIOUS opinions have been held as to the zoological place of the fossil known as *Receptaculites*, occurring in the Silurian system, but represented by a fine species throughout the Devonian rocks of the Rhenish system. It has been referred by some to the Sponges, and by others to the Foraminifera. Dr. Gümbel's late microscopic researches on the internal structure of this interesting fossil place its nature in a clear light. As already described by

Billings, it possesses a skeleton consisting of two walls or floors, each made up of rhombic plates, fitting in one to another; separating and supporting the two floors or decks are a great number of thickish, calcareous, vascular columns, which are traversed by an internal canal with ramifications in each of the floors. After illustrating this structure, Gümbel points out that the calcareous skeleton, therefore, possesses an anastomosing canal-system; and hence the columns are not analogues of Sponge-spicules, nor is the whole structure equivalent to the embryonal form of Sponges, as regarded by Billings; but, on the contrary, corresponds closely with *Foraminifera*, among which it forms a genus, not of the *Orbitolitidæ*, as suggested by Salter, but strictly near the *Dactyloporidæ*, as an allied family—that of the *Receptaculidæ*. These conclusions are clearly illustrated by numerous accurate drawings from Dr. Gümbel's microscopic sections of *Receptaculites*.

The bibliography and history of opinion as to the nature of this fossil creature are fully given by Dr. Gümbel. The localities and range are also indicated. *Ischadites* and *Tetragonis* have not yet been submitted to close study; but the author is of opinion that, though closely allied to *Receptaculites*, they have specific, if not subgeneric, differences. A synonymic list of the known fossil forms coming under these names is given at pages 38–40; and other probably allied forms are also enumerated. T. R. J.

REVIEWS.

◆

Description Géologique de la Craie de l'Ile de Wight. Par M. Charles Barrois, Préparateur de Géologie à la Faculté des Sciences de Lille.

HARDLY any spot in the United Kingdom is so attractive to all classes of people as the Isle of Wight. To the geologist, however, this island is of peculiar interest, owing to the number of formations there represented, and the admirable cliff sections and fruitful fossiliferous localities around its coast. Hence it has been the subject of numerous papers and memoirs. But room has still been left for further research, of which M. Barrois has availed himself, and in the present paper he has given the result of his observations.

After reviewing the literature on the subject, the author proceeds to give a topographical sketch of the position of the Chalk, which is divided by an anticlinal line running east and west along the island into two portions, dipping in opposite directions.

The southern mass rests on the Upper Greensand, and consists of Chloritic Marl (zone of *Am. laticlavius*), overlain by the Chalk Marl (zone of *Scaphites æqualis*). This latter is a compact, greyish-blue chalk, with conchoidal fracture, containing numerous nodules of iron pyrites, about 115 feet thick. The general dip is from 5 to 10 degrees to the south.

The flints in this district, though apparently intact, fall to pieces

touched. The Chalk here is capped by a gravel containing
ous flints, in which M. Barrois found an implement.

northern mass, which traverses the island in an east and west
on from Culver Cliff to the Needles, is divided by the author
ree portions. The first extends from the Needles to Calbourne
ı, the second from Calbourne Bottom to the Medina, and the
rom the Medina to Culver Cliff. In the two lateral portions
ls are higher and the dip of the beds greater than in the central
In the former the dip is from 40° to 80°, whilst in the latter
ıly from 10° to 45°.

mass is also divided by four north and south faults. Through
st important of these the Medina flows; the next has formed
rne Bottom, and gives rise to the spring at Calbourne; whilst
her fractures have allowed the Yar and Eastern Yar to cut
h the Chalk at those points.

author divides the Chalk composing this ridge of hills into
lowing zones, taking them in ascending order:

**Chalk Marl (zone of *Scaphites æqualis*). Blue-grey, marly
one, with conchoidal fracture, containing nodules of iron pyrites.
s abundant in lower portion.**

—Craie Marneuse—Chalk without flints:

one of *Inoceramus labiatus*.—Hard, dry, yellowish-white Chalk, marking but
, nodular at the base for about two yards, but becoming more homogeneous as
s up. Quarried at Mount Joy and Mefsty Down.

one of *Terebratulina gracilis*.—About 16 feet thick. Towards the upper part
nd of nodules of hard Chalk covered with a green coating, and containing
4½ per cent. of phosphate of lime. This band, called "Chalk Rock" by Mr.
ker, can be traced from one end of the island to the other. A stratum of
less marly than that below the nodules, succeeds them, containing a large
r of *T. gracilis*, but no flints. This again is covered by a layer of black clay,
ss than one to four inches thick. This layer of clay the author considers to be
e line of demarcation between the Chalk without and the Chalk with flints,
eparates two distinct zones of life; whereas the "Chalk Rock," which Mr.
ker took as the dividing line, does not do so.

.—Chalk with flints:

one of *Holaster planus*.—Hard nodular Chalk, full of fossils, about 66 feet
The nodules are extremely hard, and of a yellowish-white colour, the Chalk
n them being softer and greenish-grey in colour. Bands of tabular flint are
ous; the flint nodules are small and scattered irregularly through the mass.

one of *Micraster cor-anguinum*.—Chalk much fissured. Flints abundant in
nd tabular masses. Sections scarce. About 165 feet thick.

one of *Micraster cor-testudinarum*.—Compact, soft, dazzling-white Chalk,
ing black angular flints in rows, from 20 inches to 3 feet apart, which towards
per part are replaced by bands of grey marl. Fossils are not numerous.
ess about 550 feet.

one of *Belemnitellæ*.—In the lower portion the Chalk is white, marks well,
ntains many large black flints. *Echinocorys gibbus* abundant, along with
itella mucronata and *B. quadrata*. The upper portion is softer, and marks
asily. The flints are smoky-grey coloured. *B. mucronata* with *Magas*
s very abundant. The latter is not found in the lower portion.

Arreton Down Quarry this zone is found superimposed upon
st. The distinction between these two zones rests on palæon-
ical evidence only.

e Chalk with *Belemnitellæ* is directly covered by the Tertiaries,
s in many places eroded and pierced with sand-pipes. A deep

cutting in the high road near Apes Down exhibits the dazzling white chalk on one side, and the dark red Woolwich and Reading Beds on the other.

The following conclusions are drawn by M. Barrois:

I.—The Cretaceous beds of the Isle of Wight are capable of being divided into the same palæontological zones as those of the North of France have been by M. Hébert.

II.—There are three beds of nodules which can be traced from one end of the island to the other that are of stratigraphical importance. First, the one at the base of the *Inoceramus labiatus* zone, corresponding to the Totternhoe Stone of Oxfordshire, etc.; secondly, the one in the upper part of the *Terebratulina gracilis* zone, the 'Chalk Rock' of Mr. Whitaker; and thirdly, the base of the *Holaster planus* zone.

III.—The form assumed by the chain of Cretaceous hills traversing the island and the different inclinations of the beds composing them are easily understood if the existence of the four above-named faults perpendicular to the beds be admitted.

The paper is illustrated by several woodcuts and an excellent coloured map; there are also lists of the fossils obtained by M. Barrois in the different zones. B. B. W.

REPORTS AND PROCEEDINGS.

Geological Society of London.—I.—January 5, 1876.—John Evans, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "Historical and Personal Evidences of Subsidence[1] beneath the Sea, mainly if not entirely in the fourteenth and fifteenth centuries, of several tracts of Land which formerly constituted parts of the Isle of Jersey." By R. A. Peacock, Esq., C.E., F.G.S.

In this paper the author brings forward a great number of details, derived in part from personal observations and in part from ancient documents, to prove that a considerable submergence of land has taken place round the island of Jersey within comparatively recent times. He referred principally to the existence of a submerged forest in the Bay of St. Ouen, evidenced by the existence of stumps of trees in the sea-bottom there, and by the traditional fact that up to quite a late period fees were paid for privileges connected with the forest of St. Ouen, although the forest itself had long previously disappeared beneath the sea. From the evidence it would appear that the submergence took place at the end of the fourteenth or the beginning of the fifteenth century. The author also noticed the occurrence of peat and submarine trees in the little bay of Greve de Lecq on the north side of Jersey, and especially referred to the evidence afforded by the Ecrehous rocks and Maitre Isle, there having been in the latter a priory or chapel, supported by rents derived from the parish of Ecrehous, which is now represented only by a small islet, with the ruins of an ecclesiastical building upon it, and a range of rocks protruding but little above the sea.

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[1] *See Mr. Danby's letter* on the Isle of Jersey in this number, p. 143.—Ed. Geol. Mag.

. "The Physical Conditions under which the Upper Silurian and eeding Palæozoic Rocks were probably deposited over the thern Hemisphere." By Henry Hicks, Esq., F.G.S.

this paper the author, after pointing out the lines of depression ained in his former paper to the Society, now further elaborated views then propounded by him by carrying his examination into higher Palæozoic series and into more extensive areas. Beginning he top of the Lower Silurian, where he first recognizes any ence of a break in the Palæozoic rocks, he proceeded to show this break was restricted to very limited areas, and almost en-y confined to the parts which had been first submerged, and re the greatest thickness of sediment had accumulated on both s of the Atlantic, and hence where the pre-Cambrian crust had me thinnest. On the European side this break occurred where anic action had taken place, and has doubtless to be attributed to combined action of upheaval of portions of the crust and the ping up of volcanic material, the latter in some cases forming anic islets of considerable extent. He strongly objected to look n these breaks, even in the British area, where they are most ked, as evidence of a want of continuity over other and far greater s; or to admit that even where there was conformity in the rocks his point, "great intervals of time are indicated, unrepresented by tified formations." The conformity found in extensive and widely arated areas is proof also that a gradual contraction took place of enormous portion of the crust in the northern hemisphere in læozoic times; and the breaks at the close of the Lower Silurian l in the Devonian are not indications of an arrest in the general sidence. After indicating the changes which must have taken ce in the climate from this gradual spreading of the water and the dence to be derived from the consideration of the deposits and the nas, the author drew the following general conclusions:—

1. That the condition of the northern hemisphere at the beginning Palæozoic time was that of immense continents in the higher latiles, traversed by mountainous ranges of great height, but with a neral inclination of the surface, on the one side (European) to the th-west and south, and on the other side (American) to the th-east and south.

2. That these continents were probably covered, at least in their her parts, with ice and snow; and that much loose material had sequently accumulated over the plains and deeper parts, ready to denuded off as each part became submerged. This would account the enormous thickness of conglomerates, with boulders, grits, d sandstones, found in the early Cambrian rocks, and also to a tain extent for their barrenness in organic remains.

3. That the depression over the European and American areas s general from at least the latitude of 30° northwards; that the rts bordering the Atlantic were the first to become submerged; lower latitudes also before the higher.

4. That the depression could not have been less altogether, for whole of the Palæozoic, than 50,000 feet; and that conform-

able sediments to that extent are found over those parts of the areas first submerged, and which remained undisturbed. That volcanic action was chiefly confined to parts of the regions which became first submerged. That the immediate cause of these outbursts was the weakness of the pre-Cambrian crust at those parts, from the great depression that had taken place, it being too thin there to resist the pressure from within, and to bear the weight of the superincumbent mass of soft sediment.

5. That the seat of volcanic action at this time was at a depth of probably not less than 25 miles, as sediments which were depressed to a depth of from 9 to 10 miles do not indicate that they had been subjected to the effect of any great amount of heat, and are free from metamorphism.

6. That the climate at the early part of Palæozoic time was one of very considerable, if not extreme cold, and that it became gradually milder after each period of depression. That towards the close of the Palæozoic epoch, in consequence of the elevation of very large areas, and to a great height, the climate became again more rigorous in character.

7. That the various changes which took place over the northern latitudes during Laurentian and Palæozoic times allowed marine and land life to develope and progress in those areas at interrupted periods only; consequently most of the progressive changes in the life had to take place in more equatorial areas, where the sea-bottom was less disturbed, and where the temperature was more equable. Any imperfection therefore in the Palæontological record belonging to these early times should be attributed to these and like circumstances; for wherever an approach to a complete record of any part of the chain is preserved to us, the evidence points unmistakably to an order of development, through a process of evolution from lower to higher grades of life.

II.—January 19, 1876.—John Evans, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "On some Unicellular Algæ parasitic within Silurian and Tertiary Corals, with a notice of their presence in *Calceola sandalina* and other Fossils." By Prof. P. Martin Duncan, F.R.S., V.P.G.S., etc.

After noticing the works of Quekett, Rose, Wedl, and Kölliker, which refer to the existence of minute parasitic borings in recent corals, recent shells, and a few fossil mollusca, the author describes the appearance presented by a great system of branching canals of about 0·003 millim. in diameter, in a Thamnastræan from the Lower Cainozoic of Tasmania. He then proceeds to examine the corresponding tubes in *Goniophyllum pyramidale* from the Upper Silurian formation. In sections of that Coral one set of tubes runs far into the hard structure; these are straight, cylindrical, and contain the remains of vegetable matter. Neither these tubes, nor any others of the same parasite, have a proper wall; they are simply excavations, the filiform alga replacing the organic and calcareous matter abstracted. In some places the dark carbonaceous matter is

sent, and the lumen of the tube is distinguishable by the ready
ssage of transmitted light. Other tubes run parallel to the wall,
d enter by openings not larger than their common calibre. But
ere are others which have a larger diameter, and in which the
tioplasm appears to have collected in masses resembling conidia;
d where fossilization has destroyed much of the continuity of a
be, a series of dark and more or less spherical bodies may be seen.
some places, especially in the spaces between the minute curved
sepiments and tabulæ, hosts of globular spores, with or without
bes emanating from them, may be seen. In *Calceola sandalina*
rresponding structures exist sometimes, and the method of entry
the parasite can be examined. The author gave two instances,
e of which was seen in section. A decided flask-shaped cavity
isted in the wall of the shell, opening outwards and rounded and
osed inwards. It was crowded with globular spores (oospores),
d these, where near the sides, had penetrated the hard shell, and
us gave a rugged and hairy appearance to the outline of the
sk-shaped cavity. After noticing minute structures in a Bra-
iopod included in a Silurian Coral, and in a Lower Silurian Fora-
inifer, the author asserted, from the results of his late researches
on the algæ parasitic in Corals out of his own aquarium, that
e fossil and recent forms are analogous in shape, size, and distri-
ition. He considers that the old parasite resembles *Saprolegnia*
rox in its habit; and as he considers that *Empusina*, *Sapro-*
pnia, and *Achlya*—members of the Protista—are the same
ganisms, living under different physical conditions, he names the
d form *Palæachlya penetrans*; and he believes that it entered the
all by the spores fixing on to the organic matter, and growing by
s assimilation, and that carbonic anhydride was evolved. He con-
ders that this acid, assisted by the force of growth and the move-
ent of the cytioplasm, are sufficient to account for the presence of
ıe tubes. Finally, the author draws attention to the probable
milarity of external conditions in the Silurian and present times,
ıd to the wonderful persistence of form of this low member of the
rotista.

2. "How Anglesey became an Island." By Prof. A. C. Ramsay,
L.D., F.R.S., V.P.G.S.

The author described and illustrated by sections drawn to scale
ıe contours of the island of Anglesey and the adjacent parts of
arnarvonshire, and noticed that the whole island may be regarded
s a gritty undulating plain, the higher parts of which attain an
verage elevation of from 200 to 300 feet above the sea-level.
imilar conditions are presented by the country for some miles on
ıe other side of the straits, and in both the general trend of the
alleys is north-east and south-west. The rock surfaces, when bare,
ıow glacial striæ running generally in a direction 30° to 40° west
f south.

The author indicated that the great upheavals of the crust of the
arth forming mountains took place long before the commencement
f the Glacial epoch, and that ordinary agents of denudation had

ample time for the formation in mountain regions of deep valleys, down which, during the Glacial epoch, glaciers would take their course. He noticed the evidence of this local glaciation furnished by the striation of the Welsh mountains, from which he inferred that these mountains as a whole were not overridden by a great ice-sheet coming from the north, and he described the course of the glaciers flowing from the north-west slopes of Snowdonia as being in the directions west, north-west, and north. These glaciers, however, did not reach the region now occupied by the Menai Straits, but spread out in broad fans on the north-western slopes of the hills now overlooking the Straits, a fact indicated by the directions of the glacial striæ in these parts. Anglesey, therefore, was not glaciated by ice-masses coming from Snowdonia; and as the striations on that island point directly towards the mountains of Cumberland, the author inferred that these markings were produced by a great ice-flow coming from that region, reinforced probably by ice-streams from the north of Scotland, and which were large and powerful enough to prevent the glaciers of Llanberis and Nantffrancon from encroaching on the territory of Anglesey.

The author described the rocks bordering the Straits as consisting of nearly horizontal Carboniferous strata, which, from appearances, must once have filled the whole of the region now occupied by the straits. He considered that the softer shaly, sandy, and marly beds, remains of some of which are still to be seen on the coast, were swept away by the action of the great glacier coming from the north-east, forming a valley now occupied by the sea; and in support of this view he cited the valley of Malldraeth Marsh, running across Anglesey, parallel to that of the Menai Straits, about 4 miles to the north-west, which a very slight change in conditions would convert into a fjord, differing from the Straits only in being closed at the north-east end.

CORRESPONDENCE.

[*The subjoined letters, from* the Rev. J. F. Blake *and* Prof. G. A. Lebour, *were, by an oversight, omitted to be published in last month's* Magazine; *the Editor begs to apologise for the unintentional delay which has occurred.*]

LOWER SILURIAN FORAMINIFERA.

Sir,—In some thin-bedded, finely-laminated shales, referred by the Geological Survey to the Caradoc series, at a spot about eight miles east of Aberystwith, in the neighbourhood of the lead-mines, I noticed a slab covered by numerous hollows, coloured red as if from oxide of iron, and of an elongated shape. On examining these hollows more carefully with the microscope, several of them present most perfect outlines of Dentalian Foraminifera, and two in particular present that peculiar tubular elongation for the main foramen, which is denoted by the term Ectosalenian. The walls between the [illegible] also indicated in several, though obscurely, the substance of the shell having in all cases perished. The most perfect of these hollow casts could not be distinguished from that of *Dentalina communis*, and I could venture to name other forms, but with less certainty.

As I am not aware that we have any recorded instances of Foraminifera of this modern type occurring so low down as the Lower Silurian in Britain, though they have been found in rocks of this age in Russia, I think the fact of sufficient interest to be noticed, giving us, as it does, so good an idea of the persistency of lowly-organized life from specimens in our own country. The slab is marked on the other side with the tracks of *Nereites Sedgwickei*, and is now in the Museum of the University College for Wales.

ABERYSTWITH,
November, 1875.

J. F. BLAKE.

RANGE OF *SACCAMMINA CARTERI*, BRADY.

SIR,—If Mr. Bennie had read the note he quotes in its proper association, I think he would not have written the letter which appears in the January Number of the GEOLOGICAL MAGAZINE, though we, its readers, might thereby have lost a valuable contribution to our knowledge of the distribution of *Saccammina*.

The text of my paper runs thus: "Nearly all the organisms which it was supposed characterized the Yoredales in Northumberland have now been found in the lower beds of the Carboniferous Series. . . ." Then comes the note: "Up to the present time, the well-marked foraminifer *Saccammina Carteri*, Brady, is apparently limited to a bed in the Upper or Yoredale part of the series, viz. the Four-fathom Limestone." (GEOL. MAG., 1875, Dec. II. Vol. II. pp. 542, 543.)

It will be seen that the words "in Northumberland" apply equally to the note and to the text. And *as Saccammina has never yet been found out of the Four-fathom Limestone in Northumberland,* the statement needs no correction.

If Mr. Bennie will turn to page 329 of the "Geological Record" for 1874, he will see an abstract of Mr. Young's paper on *Saccammina*, signed by myself. The explanation of Sheet 23 of the Geological Survey of Scotland has likewise been known to me ever since its issue, and the localities for *Saccammina* duly noted.

That the exact horizon of the Dunbar locality, which I had been given to understand was considered as doubtful, has been satisfactorily determined, I am exceedingly glad to hear; the more so as perhaps the most remarkable specimen of the fossil in question which has yet been found is one which was collected in that neighbourhood many years ago by Mr. F. M. Balfour, of Trinity College, Cambridge.

Far from imagining, as Mr. Bennie seems to imply, that *Saccammina* was limited to one horizon *out of Northumberland*, I have for the last few years followed with great interest the almost daily increase of its known range, both geographical and geological.

I think that when Mr. Bennie sees the list of localities in which [illegible] has been found in the forthcoming Monograph on Carboniferous and Permian Foraminifera by my friend Mr. H. B. Brady, F.R.S. He himself will be surprised at their number.

College of Physical Science, G. A. Lebour.
Newcastle-on-Tyne, [illegible] Jan. [illegible]

THE ORIGIN OF LAKE BASINS.

Sir,—It is not my intention to reply to the detailed arguments advanced by Mr. Judd in his attempt to prove that my theory "on the *glacial* origin of *certain* Lakes"[*] is untenable by persons having an adequate knowledge of ordinary physical geological phenomena. Were I to do so, I should have to repeat old arguments used by me in reply to the objections long ago raised by the late Sir R. Murchison and Sir Charles Lyell, objections very similar to those used by Mr. Judd, and which seemed to me and others easily disposed of. If any one cares to look into the early history of the subject, he will find them replied to in the volumes of the *Philosophical Magazine* for [illegible] and [illegible]. To other objectors I paid no attention, partly because the late Professor Jukes and others, of their own accord, did it perfectly well for me, and partly because I can generally employ my time better than in geological controversy.

Two or three points, however, I will notice.

In the first place, from anything that appears in Mr. Judd's paper, the reader might suppose that I attributed the formation of *all* rock-bound lake-basins to the action of glaciers, in spite of a statement, in a note to the original memoir, that "many lie in craters of extinct volcanos, some, no doubt, in areas of special subsidence, and others may be due to causes of which I know nothing." In the same memoir I also in several places insist on the occurrence of moraine-dammed lakes, and also speak of others dammed up by irregular accumulations of the original drifts of the Glacial epoch.

The same facts are again insisted on in my "Physical Geology and Geography of Great Britain," with the addition of lakes dammed by eskers; and besides, to prevent all misconception, I mentioned the African lakes, alluded to by Mr. Judd, as probably, in my opinion, like the Caspian, being parts of old sea-bottoms. I should certainly never have been so wild as to attribute the hollow of the Dead Sea to glacial erosion, though Mr. Judd seems to think that some persons may do so, confining myself as I did, and do, to the "origin of certain lakes" in well-recognized glaciated regions.

Secondly, it seems strange to me that Mr. Judd should have selected Lake Balaton as a *crucial test* to the theory of ice erosion. I never knew any one who denied the well-known fact that lakes may be and have been formed by subsidence in volcanic areas. I have seen examples of such, and have read of and believed in many others, both in Europe and America. Earthquake shocks have also been known to produce changes of level that gave origin to lakes, and ordinary landslips do the same. That there are great areas of inland drainage full of salt lakes, some of them below the level of the sea, is another *piece of* popular knowledge, and I never heard of any one who *attributed* all of these hollows to glacial erosion.

All these kinds of lakes and many others, "on the origin of which I know nothing," have however no conclusive bearing on the occurrence of such *a vast number* of rock-bound lake-basins in all countries that I have examined which have been covered more or less by large glaciers, and their comparative absence in regions, however much disturbed their rocks may be, which have not undergone glaciation; and I would ask any one who counts all the lakes and lakelets visible from the top of Suilven and other Scotch mountains to ask himself if he can rationally account for them, scattered as they are broadcast over the plateaux, and in the deeper glacier-valleys, on the hypothesis of movements in the rocks of the country, specially suitable for the production of a crowded series of lakes large and small?

It would also be an interesting exercise to count the lakes in Lewes, a great many of which have been proved by a "Scotch geologist" to be rock-bound basins, and to account for them in that low island by one or more special disturbances of the rocks.

Authority in matters of faith, whether geological or otherwise, is a most important element, and the authority of all "the distinguished geologists in Germany, Switzerland, France and Italy," "with one solitary exception," is adduced to show that "the hypothesis of the glacier-erosion of the basins" of the Alpine lakes is "both unnecessary and inadequate." I presume that solitary exception to be my distinguished friend Gastaldi, who, after holding an opposite opinion for years, at length adopted my views in a frank and courageous manner. But that high authority is not a "solitary exception." I could name another Italian geologist of weight, who years ago adopted my views with regard to the Alpine lakes, and there may be more of them for aught I know to the contrary. As yet, however, such avowed authorities are scarce on the Continent of Europe; but years ago I was told by a well-known Swedish geologist, that he never understood the meaning of many of the lakes of that country till he read my paper. English geologists will probably soon have an opportunity of reading more upon the subject from another Scandinavian geologist, who lately wrote to me, that the mode of formation of such lakes and the basin-shaped inner depths in Fjords, on any other hypothesis than mine, reduced the subject to "mere chaos."

Mr. Judd writes of "the strenuous efforts which have recently been made to resuscitate the doctrine of the erosion of lake-basins by ice." The doctrine not only did not die, but it did not even fall asleep. First, it was immediately accepted by Jukes, Tyndall, and Huxley, fifteen years ago, and since then my adherents have constantly increased. Among them I may count Dr. Newberry and others in the United States, a result that in some cases was probably helped by the unsolicited republication of my original memoir in *Silliman's Journal* in 1863. Next came the late Sir Wm. Logan, and the well-known geologists in New Zealand, some half dozen in number; also, one of the best geologists in India, if not more; and more geologists in Britain than I care to count, the names of some of whom are widely known wherever geology is cultivated. In fact, I have every reason to be more than satisfied with the progress of what

Mr. Judd calls a hypothesis, and I call a theory. It never occurred to me that even in number they could be designated "an inconsiderable minority of geologists," and I think I am justified in calling them a *considerable* number, not only considered as an aggregate of units, but also in one of the dictionary senses of the word considerable, "worthy of respect or attention." That the already considerable number is still growing is not disagreeable to me, and it was with pleasure that not long ago, in debate on one of Mr. Ward's papers at the Geological Society, I heard my always courteous and consistent opponent Mr. Bonney yield the question, as I understood him, as far as the Cumberland lakes are concerned, though he reserved those of Italy.

It is now eleven years since I replied to the objections raised to my theory by Sir Charles Lyell. It is quite contrary to my ordinary habits to indulge in scientific controversy, or to trouble myself about objectors and objections, feeling sure that if a theory be good, it will in the long run speed well; if bad, it will die. I also believe that opposition at first, and a subsequent slow and growing accretion of adherents, is far better and more durable than hasty acceptance; and I would not have written this letter, had it not been that I am weary of every now and then being accused of attributing the origin of all rock-bound basins to glacial erosion, or of its being left to inference, that I may be one of those who believe, "that all the existing lake-basins are to be assumed to have been produced by ice-erosion."

After a careful reading of Mr. Judd's paper, I feel, with others, that his arguments are very far from having "*demonstrated* that the basins of the largest lakes in our own islands, in the Alpine regions of Europe, and in equatorial Africa, respectively [this last no one that I know ever supposed], *could not possibly* have been formed by the supposed excavating power of ice." Some persons may also perceive that a definite erosive power, whether adequate or not, was in my case cited in given regions in which no one denies the former existence of that power; whereas in the other case of rock-bound lakes in old glacier non-volcanic regions, disturbances of rocks have to be assumed without the possibility of special demonstration, at all events in a prodigious number of cases. ANDREW C. RAMSAY.

Postscript.—The matter seems to me to bear a resemblance to the long celebrated case of Touchstone *versus* "a certain courtier," *in re* "the cut of a beard." I assert that my lakes are very "well cut." The objector replied in the terms of "the third degree," and thus "he disabled my judgment." In our case the altercation may stop here without any danger of its being continued as far as "the seventh degree." Mr. Judd's argument seems to allow that there is "much virtue in *if*." Lake Balaton was formed *so*, and *if* so, then the presumed glacier-scooped lakes were in his opinion formed more or less like Lake Balaton. What I said I said clearly, and made certain reservations. Mr. Judd, satisfied with his judgment, as I am with mine, makes no reservations of any value in my favour, and I shall be well content to let the matter rest there. Let it be hoped that we have "measured (s)words and parted."—A. C. R.

GEOLOGICAL SURVEY OFFICE,
MUSEUM: JERMYN STREET, S.W.

ORIGIN OF LAKE BASINS.

Sir,—I observe that Mr. Judd, in the January Number of the Geological Magazine ("On the Origin of Lake Balaton in Hungary"), asserts that he has "demonstrated that the basins of the largest lakes in our islands, in the Alpine regions of Europe, and in equatorial Africa, respectively, *could not possibly* have been formed by the supposed excavating power of ice." (The italics are Mr. Judd's.) He has also "shown," he says, "that in each of these cases there is the strongest ground for believing the districts in question to have been subjected to powerful subterranean movements; and that these were quite competent to produce the depressions in question." Finally, he waxes still bolder in the statement of his beliefs, and is evidently of opinion that all smaller rock-basins must have originated in the same way. What, then, is that magic process of reasoning which has enabled Mr. Judd to arrive, with so much confidence, at these uncompromising and comprehensive conclusions, and the cogency of which has appeared to him so great as to justify some very positive, not to say dogmatic, utterances, and a general oracular tone which is surely rather *de trop?* Briefly stated, his argument is as follows:—

Lake Balaton (30 or 40 feet in depth) occupies a depression, the longer axis of which coincides with a line of volcanic action; Lough Neagh probably lies in a preglacial hollow; the Valley of the Jordan, with its lakes (Merom, Tiberias, and Asphaltites), is probably an area of subsidence; Victoria Nyanza may perhaps owe its origin to volcanic disturbances:

These lakes represent the principal types of lake-basins which exist upon the earth:

Therefore rock-basins "*may* have had their origin in those changes of level resulting from the subterranean movements which have accompanied volcanic action;" and, "*as a matter of fact,* the largest lakes in the British Islands and in the Alpine regions of Europe, respectively, and not improbably the vast sheets of water in Central Africa also, *have been* so formed, and *could not possibly be* the result of glacier-erosion." (These italics are mine.)

This is certainly a remarkable argument, but of a kind which, if it were taken for a model, might lead to curious results. For example, it would not be difficult to "demonstrate," after this manner, that all men are born in lawful wedlock. Thus:—

A is a good man, B is a bad man, C is neither good nor bad but indifferent: all three may have been, and were, I believe, born in lawful wedlock:

A, B, and C represent very fairly the principal types of men:

Therefore, men may have been born in lawful wedlock, and, "as a matter of fact," all are legitimate, and none can possibly be the offspring of unmarried parents.

Now I ask whether this brilliant syllogism is a whit less feebly-forcible and convincing than the argument upon which Mr. Judd has founded so much strong language. Exception might easily be taken to many of the author's statements, but it is not necessary to go over his paper in detail. He has advanced nothing new—nothing which has not already been answered by Professor Ramsay and others. One cannot help remarking, however, that it does seem strange that he should quietly ignore the fact that no supporter of the glacial erosion theory has ever asserted that all rock-basins are of glacial origin. Will he kindly tell us what glacialist has expressed disbelief in the existence of special areas of subsidence, or which of us has maintained that volcanic action and the movements accompanying that action cannot possibly have resulted in the formation of lake-basins. He states that I appear to assume that faults "can produce no effect at the surface." I neither assume nor assert that such is the case, as any unprejudiced reader of the passage referred to by Mr. Judd cannot fail to see. Professor Ramsay and they who follow him have all along been careful to admit that lakes are by no means exclusively of glacial origin. They have not ridden their hobby to death, but this is just what Mr. Judd has done with his along the shores of "Lake Balaton in Hungary."

GEOLOGICAL SURVEY, PERTH, JAMES GEIKIE.
31st January, 1876.

MR. JUDD AND THE GLACIAL EROSION OF LAKES.

SIR,—I have read Mr. Judd's paper on the origin of Lake Balaton in Hungary[1] with interest, and also his concluding observations, in which he proceeds to argue from the special to the general against the views of the "Scotch Geologists" regarding the glacial origin of lakes. I think it will occur to most readers, that however ably Mr. Judd has stated his case, his conclusions are not warranted by his facts; and that, in bringing the cases of certain large lakes in Ireland, Hungary, the Holy Land, and Central Africa, as evidences against the truth of the views propounded and illustrated by Professor Ramsay, he has not kept within that logical groove of reasoning for which most of his papers are distinguished.

Without wishing to enter the lists with the author of the paper, I venture to state two or three points on which his conclusions are, as it seems to me, open to objection. In summing up he says:[2] "We have demonstrated that the basins of the largest lakes in our own islands, in the Alpine regions of Europe, and in equatorial Africa, could not possibly have been formed by the supposed excavating power of ice. We have also shown that in each of these cases there is the strongest ground for believing the districts in question to have been subjected to powerful subterranean movements; and that these were quite competent to produce the depressions in question." Well, we may admit that Lough Neagh, Lake Balaton, the great African Lakes, and, I will add, the Dead Sea and Jordan Valley, were not and could not have been formed by glacial erosion. But after this admission, does it by any means follow that Loch Lomond, Lough Doon,[3] Windermere, the Welsh tarns and lakes, and some of the lakes on both sides of the Alps, were not so formed? Surely Mr. Judd will not venture on such a conclusion; nor will any one who has had a wide experience of the ways and means by which terrestrial features have been modelled. Dame Nature is not so short-handed, that where one agency fails, she cannot find another. If Vulcan is at work in one place, so also is the Ice King of the North in another. For my part, I believe that in the formation of lakes numerous physical causes have at various times, and in divers places, come into play. In the Jordan Valley it may be concluded, from the scanty observations of travellers regarding its geology, that there has been a great fracture ranging along the base of the Moabite table land. In the case of Balaton Lake there may have been a subsidence in a volcanic district; in that of Lough Neagh, fractures of the strata before the Glacial Period; in many large lakes in the centre of Ireland, there has been the dissolution of the limestone by water charged with carbonic acid gas; and in the Cheshire plains there has been subsidence due to the melting of subterranean beds of salt, as Mr. Ormerod long since suggested. These are all diverse processes by which lakes are formed by other than glacial erosion. But none of them apply in the cases of the rock-basins of British mountains and other districts where the evidences of glacial erosion are so striking, and where there are no evidences of recent fractures of the strata, nor of volcanic terrestrial movements, nor of solution of calcareous beds, nor of solution of beds of salt. On the other hand, in default of other agencies, we are forced to recognize the influence of those which have evidently been at work in these districts; and I cannot think that, in throwing over so completely the theory of glacial erosion for all lakes, Mr. Judd has sufficiently weighed the grounds for its acceptance, which have from time to time been advanced by its author, Professor Ramsay, or by those who support his views, such as Gastaldi of Turin, or James Geikie amongst the "Scotch Geologists."

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[1] GEOL. MAG. No. 139, January, 1876, p. 5.

[2] *Ibid.* p. 15.

[3] See J. Geikie, "The Great Ice Age," p. 294.

I may observe, in conclusion, that both in the original memoir in the Journal of the Geological Society, and in the *Physical Geology of Great Britain*, Professor Ramsay especially eliminates "crater-lakes, lagoons, and the lakes of Central Africa," from the class of lakes to which his theory applies; so that Mr. Judd's objection has been anticipated by the author of the theory himself. (Phys. Geol. and Geog., 3rd ed. p. 173.)

GEOLOGICAL SURVEY OFFICE, DUBLIN,
January, 1876.

EDWARD HULL.

MR. JUDD ON GLACIAL EROSION AND SUBAERIAL DENUDATION.

SIR,—To fight other people's battles, especially when the other people are perfectly well able to take care of themselves, is palpably unnecessary, and might smack of meddlesome interference; besides well-intentioned advocacy is liable to damage even a good case, unless the advocate is specially fitted for his task; and then—but no, I won't go on. I have given reason enough why I should not try to discuss the arguments advanced by Mr. Judd in your January Number against the theory of the Glacial Erosion of Rock Basins.

But there are one or two points in that paper which I do feel less diffidence in approaching. With a large portion of Mr. Judd's remarks I am confident that a very considerable majority, if not all, even of the most enthusiastic supporters of the theory of Glacial Erosion and of the doctrine of the sculpturing power of Subaerial Denudation, will most cordially agree; indeed, if a few paragraphs had been omitted, I doubt if any one would have been found to raise a word against the paper. But in his anxiety to make his arguments as clenching as possible, Mr. Judd seems to me to have resorted to that easy and safe way of securing a triumph, which consists in setting up a dummy adversary in order to have the satisfaction of knocking him down again.

Two classes of geologists are alluded to who appear to me to be pure phantoms of the imagination. The first are those who hold that "all the existing rock-basins have been produced by ice erosion." Where are these exquisite specimens of the man of one idea to be found? Who ever said that Lake Balaton, Lough Neagh, the Dead Sea, or the Victoria Nyanza were excavated by glaciers?

What I must look upon as the second dummy is the geologist who asserts that "the production of the features of the earth's surface is entirely due to the action of denuding agents, and that subterranean forces have played no part whatever in the matter." Here again I don't know where to lay my fingers on the man; if he ventures to show his face, he will assuredly receive as little mercy at the hands of geologists in general as has been accorded him by Mr. Judd. Such a doctrine is too palpably inconsistent for the veriest beginner to accept it for a moment. Before denuding agents can carve out hill and valley, they must have something to work upon; the material they have to fashion is either a derivative rock formed under water, or a crystalline rock that once lay deep down in the bowels of the earth. Without subterranean forces how are we to get a rock of either class within the reach of denudation to begin with? Again, what is it that has caused the main lines of drainage to run in many cases in the direction of the dip and directly athwart the strike of the rocks? Is it not one of the most fundamental parts of the theory, which assigns the formation of the surface to subaerial denudation, that it was the prevalent direction of the dip of the underlying rocks that determined the first slope of the surface and gave the initial direction to the flow of meteoric water? So far from subterranean forces being ignored, subaerialists have all along maintained that it was through them that the trend of the first formed rivers was decided. Further, who has been bold enough to assert that great mountain chains have been wholly cut out by denudation? Has it not been all along maintained, that while all the lesser details of their contour are due to that cause, their superior elevation is very largely owing to a concentration of the energy of subterranean forces along certain zones of the earth's surface? A theory well borne out by the excessive contortion which is always found in lofty ranges. I might add much more in support of my point, but I think I have said enough to show that the geologists who are the objects of such well-founded horror on Mr. Judd's part, are not to be found either among the advocates of the possibility of rock-basins having been scooped out by glaciers, or in the ranks of those who have with such ability insisted on the important share which subaerial denudation has played in producing the shape of the surface.

I need scarcely add that I do not write for professed geologists; to them nothing that I have said will be new, and they do not require cautioning: but there must be many of your readers who would accept a statement coming from so high an authority as Mr. Judd without question; to such I may give a word of warning, and remind them that even Homer was not exempt from the failing of an occasional nap. Whether Mr. Judd was napping, and a vivid imagination conjured up during his dreams a spectre so repulsive to a philosophical mind that there was no resource but to write him down immediately, I can't say. Some great authors are reported to have composed during sleep; but however the curious mistake into which I cannot help thinking he has fallen has arisen, all who know Mr. Judd will agree that there cannot possibly have been any intentional misrepresentation. A. H. Green.

Leeds, *February 12th*, 1876.

ELEVATION AND SUBSIDENCE OF LAND IN JERSEY.

Sir,—It may interest your readers to know that in addition to the indications of subsidence of land in Jersey, described by Mr. Peacock in his paper lately read before the Geological Society,[1] there exist indubitable proofs of elevation of the coast of the island.

Close by Elizabeth Castle in St. Aubyn's Bay, there stands the picturesque pinnacle of the Hermitage, in the rock of which St. Helerius is said to have impressed his holy body. At the base of the Hermitage, on the northern side, is a very fine raised beach. I have had an opportunity of examining this, and found it to consist of light-coloured, not very coarse, shingle and sand, containing an abundance of shells of species now flourishing on the adjacent shore. I visited this raised beach again in the autumn of 1874, intending to investigate it more carefully, and then found that, in the progress of the harbour works, it had been turfed over and rendered inaccessible.

On the opposite side of St. Helier's Harbour, under Fort Regent, there is a somewhat doubtful specimen of a raised beach. The harbour works here, however, have disclosed proof that the land stood formerly at a lower level; the workmen, in blasting and cutting back the rock (syenite), have quarried away a sea-worn cave running inland some twenty or more feet, and high enough (so the workmen informed me) to admit a man erect, and containing syenitic boulders of all sizes, rounded and shaped by the breakers.

A comparison of levels would probably facilitate the determination of the chronological sequence of these (geologically) recent subsidences and elevations of land in Jersey. I have not yet, however, had an opportunity of making it. *If* it be true that St. Helerius[2] lived in the Hermitage Rock, it is at any rate obvious that the littoral accumulation at its foot must in his time also have been a raised beach; for even a robust hermit could not have long supported life with the roaring waters rushing through the channel, locally known as Hell Gate, within a few feet of him, and effectually cutting him off from the mainland, even though this channel must then have been considerably wider than at present.

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[1] See abstract of Mr. Peacock's paper, *ante* p. 130.

[2] One antiquary fixes his date somewhere in the ninth century; another in the latter half of the sixth.

Dr. Martin Bull, of St. Helier's, informs me that at least two other raised beaches occur in the island. One of these is at the southern end of St. Owen's Bay, near La Pulente; it is about 100ft. above the present beach, and contains quantities of shells of extant species. The other is in St. Clement's Bay, between Le Hocq and Pontac.

Proofs of elevation are not confined to Jersey. A similar raised beach is passed in mounting from the Harbour of Sark by the side of the road leading into the interior of that islet.

DOWNING COLLEGE, CAMBRIDGE, T. W. DANBY.
January 25, 1876.

GLACIAL EROSION.—The subjoined Postscript deserves a place in this MAGAZINE, although the hand that penned it is now cold. It was sent too late as a rider to a letter which we published in October last (p. 524).—EDIT. GEOL. MAG.

P.S.—Follow Swaledale, Wensleydale, and all the rivers descending from the Pennine chain, through the *soft* strata, between the Permian and the *hard* gorge cut by the Humber through the Chalk Wolds. In these soft strata the separate valleys almost disappear. Atmospheric disintegration, and the *vertical* descent and erosion of rain, have worn down the hills which intervened into what is called "The Plain of York." But if, as Mr. Goodchild says, valleys are formed and *widened* by "mechanical means," be these mechanical means the *horizontal* thrust of glaciers or the *horizontal* undermining of rivers, each valley would run between two precipitous cliffs, and the Ouse and the Humber, and their tributaries should traverse what is now the Plain of York, with sides as high as the Chalk Wolds, and running up to Mr. Goodchild's "scars" and ledges on the Pennine Chain.

BROOKWOOD PARK, ALRESFORD. GEORGE GREENWOOD, Colonel.
September 24th, 1875.

MISCELLANEOUS.

AQUARIUM ROCKWORK.—The rockwork in the tanks at the New Westminster Aquarium contains a considerable amount of Portland Oolite. We understand that it was purchased from the *débris* of the Colosseum, Regent's Park, as a sandstone, and it appears to have been introduced into salt and fresh-water tanks alike without investigation as to how far it is suitable. It perhaps may do no harm, but it would be well if any one who has experience of what its effect will be, would communicate his knowledge before any animals are placed in the tanks. There is, in addition, a good supply of Carboniferous Limestone used, and in considering the conditions, it must be remembered that the water circulates constantly from tank to tank, so that the carbonate of lime will be just as present to all the inhabitants of the aquarium as to the Lamellibranchs and others it might (possibly ?) benefit.—*Nature.*

THE
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No. IV.—APRIL, 1876.

ORIGINAL ARTICLES.

I.—A Comparison between the Oldest Fossiliferous Rocks of Northern Europe.

By G. Linnarsson,
Palæontologist to the Geological Survey of Sweden.

IN a paper on "The Physical Conditions under which the Cambrian and Lower Silurian Rocks were probably deposited over the European Area,"[1] Mr. Hicks has recently put forth some opinions on the lowest fossiliferous rocks of Scandinavia and Russia, and their relations, as to age and stratigraphical characters, to those of Britain, which I think ought to be somewhat modified. The chief assertions in Mr. Hicks's paper are, that at the Pre-Cambrian period a large continent existed in Europe; that a subsidence began in the south-western part, and gradually extended to the north-eastern, which was not submerged until the Tremadoc group had been deposited over the western areas; and, finally, that the marine faunas migrated from the south-west. In order to prove these generalizations, Mr. Hicks makes a comparison between the most important Cambrian districts of Europe. He thinks that the British Cambrian rocks are the oldest, that the lowest Swedish beds are probably equivalent to the British Menevian group, and that the Russian are not older than the Arenig. Though the scantiness of the organic remains in some instances makes it very difficult, or, indeed, impossible to parallelize with certainty the oldest deposits of the various countries, it seems, however, from the palæontological facts already known, quite unquestionable that the lowest rocks of Scandinavia and Russia are older than Mr. Hicks has supposed them to be in comparison to those of Britain.

As to Scandinavia, its oldest fossiliferous rocks are: 1st, the Eophyton Sandstone; 2nd, the Fucoid Sandstone; and 3rd, the Paradoxides Schists, which together represent the Lower Cambrian according to Mr. Hicks's classification, and contain each a peculiar fauna. In the British Lower Cambrian Mr. Hicks also reckons three faunæ. Of these, however, the second and third are so nearly related that, from a merely palæontological point of view, they might well be united in one,[2] and the rocks containing them together parallelized with the Paradoxides Schists of Scandinavia. The Trilobites of the Harlech group belong, most if not all, to the same genera as those characterizing the Menevian group, for *Plutonia* is hardly anything but a *Paradoxides* with granulated shell (such as, for instance, *Paradoxides Forchhammeri*, which occurs in the higher divisions of the Swedish Paradoxides beds), and *Palæopyge* seems still to be very doubtful. The specific differences do not seem to be important enough to justify the separating of the Harlech Trilobite fauna as a distinct fauna of the same rank as that of the Menevian group. Then one could with the same reason in the Menevian group distinguish a fourth and fifth fauna and so forth, there being several divisions containing each their peculiar species. Even in the Paradoxides beds of Scandinavia there are several subdivisions, the fossils of which are, in general, specifically different, but one finds so many generic links, that one must consider them altogether as one single whole. Taken as a whole, the fauna of the Paradoxides beds of Scandinavia is quite analogous to that of the Menevian and Upper Harlech. Among the Trilobites there occur in the Paradoxides beds, besides many other genera, *Paradoxides* (*Anopolenus*, *Plutonia*), *Conocoryphe* (*Erinnys*), *Microdiscus*, *Arionellus* and *Agnostus*. Of other classes one finds *Leperditia*, *Hyolithus*, *Lingulella*, *Obolella*, *Orthis*, *Protospongia*, etc. If one may judge from the generic identities, the Paradoxides beds of Scandinavia are therefore to be parallelized to the above-cited British beds. I will not, however, positively deny that part of the Harlech beds with Trilobites are possibly older than the lowest Paradoxides beds of Sweden. Even if that be admitted, the difference of age cannot be considerable, as the general character of the faunæ is quite the same, which would hardly be the case if any long period had elapsed between their formation.

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[1] Quart. Journ. Geol. Soc. vol. xxxi. p. 552, *seqq.*

[2] Mr. Hicks has himself in several places pointed out the great resemblance between the Trilobite faunæ of the Harlech and the Menevian beds.

Below the Paradoxides beds in most Cambrian districts of Scandinavia a sudden change takes place in palæontological as well as lithological characters, though the beds are always, as far as hitherto known, quite conformable. The underlying beds are almost exclusively sandstones. Only in Norway, and perhaps in the north of Sweden, they contain any considerable intercalated beds of schists and limestone. In a palæontological respect the most striking character of these sandstones is the total absence of Trilobites. More difficult is it to affix to them any definite positive characters, as the true nature of many of their fossils is still very uncertain. The Fucoid Sandstone has yielded only two species of *Lingulidæ*, besides tracks and burrows of worms or other animals and casts of seaweeds. Far richer is the fauna of the underlying Eophyton Sandstone. It consists of Brachiopods, Pteropods and Spongiæ, besides forms of more uncertain affinities, such as *Cruziana*, *Harlania* (*Arthrophycus*) *Eophyton*, and many others. These latter forms are only casts and tracks, and give but little information of the organisms which produced them. For the identification of the strata they cannot be used, as very similar casts are found in rocks of almost every age. Thus I have seen a *Harlania* from the Rhætic beds of *Scania*, hardly distinguishable from a species occurring in the

rton Sandstone of Westrogothia. In the Upper Silurian Sand-
of Gotland I have found markings quite similar to some forms
ziana occurring in the *Eophyton* Sandstone. Even the *Eophyton*
occurs at several horizons.[1] The other fossils of the Eophyton
tone, especially a Brachiopod, which is not rare in its lowest
might be identified with more certainty, but I do not know from
n countries any species which can be suspected to be identical
them, and even their generical relations are not quite settled.
Brachiopod above referred to—I have provisionally termed it
la or *Obolus monilifer*—should in all probability form a peculiar
, judging from the structure of the shell substance. *Hyolithus*
tus and *Astylospongia radiata* have, as far as I know, no near
ves. Thus the palæontological facts alone do not yet make a
elism possible between the Cambrian Sandstones of Scan-
ia and the rocks of other countries; but, all things considered,
find no reason for believing these Scandinavian Sandstones to
ounger than the oldest English Cambrian rocks, with which
agree in position. The comparatively small thickness of the
ish Sandstones cannot be considered as an evidence of their
ging to a later and more circumscribed period than the chief
s of the British Longmynd rocks (those without Trilobites);
it is a well-known fact that the Cambrian and Silurian beds of
en are in general much thinner than their British equivalents.
. for instance, the Olenus Schists of Sweden in most places
y exceed 40 or 50 feet in thickness, nevertheless they
in equivalents of all the divisions of the British Lingula
which are stated to exceed 4000 feet. This proves that at the
us period the sediment was accumulated about one hundred times
r in the British area than in the Swedish. It is very probable
even in the oldest portions of the Cambrian era a similar, if
quite so great a disparity occurred in the rate at which the
nent was accumulated in both areas. The thickness of the
brian Sandstones of Scandinavia is very variable. In the
le of Sweden it seems to be about 100 feet; in the north and
ı it is probably more considerable. In some Norwegian districts
Cambrian Sandstones are calculated by Professor Kjerulf[2] to
ed 2000 feet in thickness, but in others, as near Christiania, they
nly thin. In Britain the rocks lying beneath the lowest beds
ining Trilobites are supposed to be about 1500 or 1600 feet in
ness, which is fifteen times that of the Scandinavian Sandstones,
re they are thinnest. Even if the superiority in the rate of the
nent forming is supposed during the oldest Cambrian period to
been only one-sixth of that during the period of the Lingula flags,
not, therefore, from stratigraphical reasons, necessary to consider
lowest Longmynd rocks of Britain to be older than the oldest
brian Sandstones of Sweden. Still less do the stratigraphical
ences support the opinion that the Longmynd rocks represent
re remote time than the Cambrian Sandstones of Norway.

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[1] Cf. Zeitschrift der Deutschen geologischen Gesellschaft, 1875, p. 245.
[2] Sparagmitfjeldet. Christiana, 1873.

If Mr. Hicks's views of the physical geography of the Cambrian period were correct, there ought to be, in the middle and upper portions of the Cambrian series of Sweden, many signs of littoral conditions, for Mr. Hicks thinks that the sea first at about the Menevian era reached the Scandinavian area, and much later still the Russian. The facts, however, rather tend to shew that most of the Swedish Cambrian rocks were deposited in a deeper sea and further from the land than the English. The Olenus beds of Sweden consist, as far as hitherto known, invariably of fine schists, containing intercalated bands and nodules of limestone.[1] The Paradoxides beds for the most part consist also of similar rocks. Only in their lower portions there occur in some places arenaceous flagstones. If one may judge from the fineness of the sediment, the whole of the Olenus beds and at least the upper portions of the Paradoxides beds—the equivalents of the British Lingula flags and Menevian group—seem, therefore, to have been deposited in a deep sea and far from the land. When we come lower in the series, we find, in Sweden as well as in Britain, many signs of littoral conditions, especially in the Eophyton Sandstone, where ripple-marks are common, and the lowest part of which is a conglomerate.

The comparative thickness of the English strata seems also to favour the idea that they were formed nearer the shore than the Swedish ones. In general more sediment is deposited near a shore than at a greater distance therefrom.

Finally, the volcanic rocks, which are said to be intercalated in the English Cambrians and Silurians, seem to point in the same direction, as volcanos seem in general to be chiefly confined to littoral regions, whether supramarine or inframarine. In the Swedish Cambrians no rocks which can be considered as volcanic are known.

The relative ages of the lowest fossiliferous rocks of Russia cannot be ascertained from their fossils alone. These are few in number; none have been identified with species occurring in other countries, and even the genera—for instance, *Schmidtia*, *Helmersenia*, and *Keyserlingia*—are mostly unknown in Scandinavia as well as in England. I must therefore confess that I have no very decided opinion of their relation to the rocks of other Cambrian districts. Thus much is, however, from stratigraphical evidences, certain, that they are far older than they are supposed to be by Mr. Hicks, who considers them to be not older than the Arenig rocks of Britain. The lowest Russian bed, the age of which can be fully ascertained from palæontological as well as stratigraphical evidences, is the bituminous schist with *Dictyonema flabelliforme*, Eichw. It is of inconsiderable thickness, but forms a well-marked horizon from St. Petersburg along the northern shore of Ehstland to Reval and Baltischport. Certainly this schist cannot be younger than the Tremadoc period. Its equivalent in Sweden, which has precisely the same lithological and palæontological characters, lies immediately above the Olenus Schists; it is older than the Lower Graptolite Schists, which correspond to the Arenig and Skiddaw rocks of Britain, and is severed from them by the Ceratopyge Limestone, which might be compared to the Upper Tremadoc of Britain. Below the Dictyonema Schist there are at St. Petersburg and in Ehstland mighty beds of sandstone and shale, several hundred feet in thickness. That they are older than the Tremadoc period is shown by their position. Any further conclusions relating to their age cannot be based on sufficient evidences. Their uppermost part seems to be nearly related to the Dictyonema Schist; the age of the lower parts remains still to be definitely settled, which will not be possible before more is known of their organic remains. Lithologically, they very much resemble the Fucoid and Eophyton Sandstones of Sweden, though they are more friable. I have, therefore, suggested that they might have stood in immediate connexion with those Swedish beds.[1] In favour of such a supposition speaks, besides their lithological characters, their position immediately above the crystalline rocks. In an opposite direction points, on the contrary, their relation to the overlying rocks, as they are immediately, and seemingly without any sharp break, overlain by a rock, the Dictyonema Schist, of much younger age than the Paradoxides Schists overlying the Fucoid Sandstone of Sweden. However this may be, it is probable that Mr. Hicks is right in thinking that the Cambrian rocks of Russia, at least in part, are deposited in a more shallow water than those of Scandinavia.

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[1] In Norway they seem to be in some districts partly replaced by sandstones and quartzites (cf. Brögger, Geol. Fören. Förhandl., Dec. 1875).

Of the Cambrian rocks of Bohemia Mr. Hicks says that "they seem to occupy an almost intermediate position, as to thickness and order of deposition, between those of Britain and those of the extreme north." This might possibly be true as to the so-called "Azoic" rocks of Mr. Barrande, respecting the age of which no positive conclusions can be drawn from fossil evidences. That they are in part older than any metamorphic rocks of Scandinavia is not impossible; and if the lower portion of the stage B, the "Przibramer Schiefer" of Austrian geologists, really lies unconformably under the upper portion of that stage and conformably over the crystalline schists, it is, indeed, rather probable. The "Primordial zone," or stage C, of Bohemia is, however, much younger than the oldest fossil-bearing strata of Scandinavia. It is most nearly related to some of the middle divisions of the Swedish Paradoxides Schists, especially to those with *Paradoxides Tessini* and those with *Paradoxides oleadicus*. That any absolutely identical species occur is not yet quite certain; but of the Primordial Trilobites of Bohemia, many are represented in the Swedish beds by very nearly allied species. Such are, for instance, *Paradoxides Tessini* and *spinosus*, *Ellipsocephalus Hoffi* and *Agnostus rex*.

It seems still to be premature to speculate on the way followed by the Cambrian faunas in their migrations. In order to do that with any certainty it would be necessary to know in every instance whether the rocks containing the same faunas are really synchronous or only "homotaxial." At present, it seems quite as probable that they were first developed in the Scandinavian area as in any other. Certainly there is no other area where there are so many forms of animal life known in the oldest Cambrian rocks as in Scandinavia.

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[1] Zeitschrift der Deutschen geologische Gesellschaft, Jahrg. 1873, p. 691.

Geological Survey Office, Stockholm, *Jan.* 22, 1876.

II.—Notes on Carboniferous Mollusca.

By R. Etheridge, Jun., F.G.S.;
Of the Geological Survey of Scotland.

(PLATE VI.)

Class Polyzoa.

Genus Vincularia, Defrance.

Vincularia Benniei, sp. nov. Plate VI. Figs. 1, 1*a*.

Specific Chars.—Polyzoarium composed of small cylindrical stems occupied by oval to hexagonal cells arranged usually in quincunx; or in oblique ascending lines; periphery of the cells erect, sharp, and granular; granules minute, numerous, and closely arranged. Here and there the angles between the cells are occupied by a small supplementary pore or pores, which are occasionally increased in number, and extend vertically between two contiguous cells, or uniting, give rise to an elongated narrow groove-like slit. Section circular.

Obs.—This little Coralline is only known to me in the form of small fragments, of which the figured specimen is a good example. The cells appear to be of one uniform depth, but the intermediate pores are perhaps not quite so deep. From *V. multangularis*, Portlock,[1] it is distinguished by the cells not being placed in furrows, and from *Favosites serialis*, Portlock,[2] which it more closely resembles, it is distinguished by the presence of the granules and pores, and the absence of the broad intercellular spaces of the former. *V. Benniei* is also closely allied to a form described by the Chevalier d'Eichwald from the *Pentamerus* Limestone of Talkhof, in Livonia, as *V. nodulosa.*[3] In this species the cells are oval with thin trenchant edges, separated one from the other by a small groove, and occasionally but not always granuled, having in addition at the upper angle a small node, larger than the granules. In *V. Benniei* the cells are, as a rule, hexagonal, the periphery always granuled, without any node which can be said to be larger than the others, and the cross section of the polyzoarium not so angulated as appears to be the case in the Russian species.

In *Ceriopora? interporosa*, Phill., the cells are oval or a little pyriform, the intercellular spaces broader and more irregular than in *V. Benniei*, and destitute of granules, and the habit is generally different. In *Millepora* (*Ceriopora*) *similis*, Phill., the cells are more elongated, and there does not appear to be any trace of interstitial pores in Phillips' figure. (Pal. Foss. t. 11, f. 32.)

Loc. and Horizon.—Shale over No. 2 Limestone (Lower Carb.

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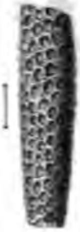
[1] Geol. Rept. London, 1843, p. 339, t. 22*a*, f. 7.

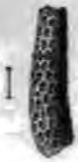
[2] *l.c.* p. 327, t. 22*a*, f. 6.

[3] *Lethæa Rossica*, 1860, vol. i. p. 402; Atlas, t. 24. f. 8.

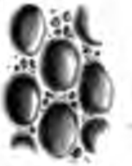
1a.



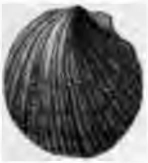
1b.



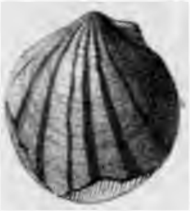
1c.



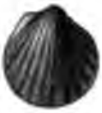
2.



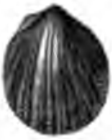
3.



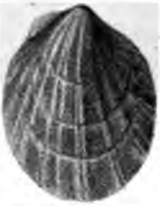
4.



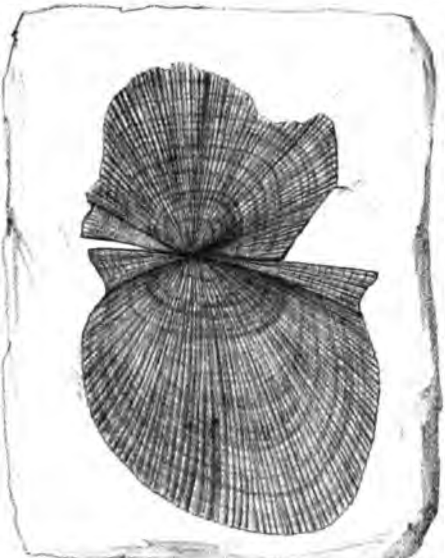
5.



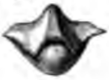
6.



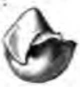
7.



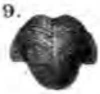
8a.



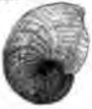
8b.



9.



10.



esbach del et lith. Mintern Bros imp.

Carboniferous Fossils.

Limestone Group), at Carlops, Peeblesshire, collected by Mr. James Bennie, after whom I beg to name the species. Head of Mouse Water, Wilsontown, Lanarkshire, in shale connected with the Hosie Limestone, collected by Mr. A. Macconochie. Collection of the Geological Survey of Scotland.

LAMELLIBRANCHIATA.

Genus AVICULOPECTEN, McCoy, 1851.

Aviculopecten planoradiatus, McCoy.

A. planoradiatus, McCoy; Annals Mag. Nat. Hist. 1851, vol. vii. p. 171.
" " ,, ; Brit. Pal. Foss., p. 489.
,, ,, Huxley and Etheridge, Cat. Foss. Mus. Pract. Geol. 1865, p. 110 (without description).
" ,, Armstrong and Young's Cat. Foss. W. Scotland, Trans. Geol. Soc. Glasgow, vol. iii. Supp. 1871, p. 47 (without description).

Obs.—To Prof. McCoy's excellent description of this shell I can only add a few notes on the ornamentation of the shell. The broad, flat, depressed ribs are covered by concentric, somewhat irregular, wavy, more or less imbricating scales. The colour markings on the specimen before me consist of fluctuating thin concentric bands passing into blotches, sometimes assuming a widely zigzag pattern, and in the present condition are of a darker colour than the remaining portions of the shell.

Loc.—Longnor, Derbyshire. Coll. Mus. Pract. Geol., London.

Aviculopecten? *sublobatus*, Phillips, Pl. VI. Figs. 2–6.

Avicula sublobata, Phil.; Geol. York. 1836, vol. ii. p. 211, t. 6, f. 25.
,, ,, Morris, Cat. Brit. Foss. 1843, p. 107 (without description).
,, ,, Tennant, Strat. List. Brit. Foss. 1847, p. 101 (without description).
,, ,, Bronn, Index Pal. Nomen. 1848, p. 142 (without description).
,, ,, D'Orbigny, Prod. de Pal. 1849, vol. i. p. 137 (without description).
,, ,, Brown, Foss. Conchology, 1849, p. 162, t. 66**, f. 32.
Aviculopecten sublobatus, Morris; Cat. Brit. Foss. 1854, 2nd ed. p. 166 (without description).
,, ,, Huxley and Etheridge, Cat. Foss. Mus. Pract. Geol. 1865, p. 110 (without description).

Sp. Chars.—Shell oval, inequilateral, convex, extended a little obliquely towards the anterior side. Anterior ear of the right valve small, scarcely divided from the body of the shell, or extending as far as the anterior margin, its remote margin slightly oblique to the hinge line (?), and marked with concentric ridges. Posterior ear small and lightly pointed, extending as far as the posterior margin of the shell, marked with delicate striæ, and one or two colour bands similar to those on the body of the shell. Hinge line short. Surface ornamented with close fine concentric striæ crossed by equally fine and delicate radiating lines, always better marked on the sides than on the body of the shell; when well preserved, these striæ give to the shell a reticulate appearance, but soon becoming worn down leave it nearly smooth. Colour markings in the form of radiating bands variously arranged.

Obs.—The ears must have been extremely delicate, as of eleven specimens which have come under my notice, only three show any traces of them. Until we are acquainted with the internal characters

FIG. 4. The same. Right valve, with numerous colour bands, and
posterior ear.
" 5. The same. Right valve, with the posterior ear.
" 6. The same. Right valve, ears not shown.
" 7. *Aviculopecten papyraceus*, Sow. A nearly complete left valve
the right. Shale 2¼ feet over Calderwood Cement Stone,
stone Group, Gleibe Quarry, E. Kilbride. Cabinet of
E. Kilbride.
" 8. *Bellerophon decussatus*, Fleming, with its greatly thickened an
with the lateral expansions over the umbilicus. Linn Quarr
fermline, Fife; shale connected with one of the L. Limest
Limestone Group). Nat. size.
" 9. and 10. *B. decussatus*, Flem., var. *undatus*, R. Etheridge, ju
Water of Leith, near Edinburgh, in shale of the Wardie Shale
Carboniferous or Calciferous Sandstone Series. (The speci
bed are usually crushed.)

III.—SOME CONSIDERATIONS ON THE PROBABLE CONDITI WHICH THE PALÆOZOIC ROCKS WERE DEPOSITED NORTHERN HEMISPHERE.

By HENRY HICKS, F.G.S.

(*With a Folding Table.*)

THE numerous excellent observations which have in recent years relative to the Palæozoic rocks i countries in the Northern Hemisphere, require that we and again attempt to summarize the results obtained, an means bring before the mind more clearly any advan knowledge of past changes which has been made, as wel those blanks which are still left for future investigations. considerations I cannot attempt to treat fully the various tions made, but I will endeavour to notice the chief results points upon which new light seems to have been thrown.

Cambrian and Lower Silurian.—Palæozoic time is cons have commenced in Europe with the deposition of the earl brian rocks, and in America, by most authorities, with the rocks. To endeavour to trace out the conditions of the Hemisphere at that early period has been one of the most i subjects which geologists have attempted to unravel in rec The researches which have been made prove conclusivel America, before the Huronian rocks were deposited, a co great extent existed there. It is evident that in Europe at there was also a continent of large size, as portions of it visible in Spain, Bohemia, France, England (Malvern[1] David's),[2] Scotland, Norway, the Loffoden Islands,[3] etc. Table it will be seen that the rocks forming this old Pre- land consist chiefly of gneiss, or granite, but there are also places beds of limestone of considerable thickness. All are found to be in a metamorphosed state, and the beddi formable to those overlying them. On both sides of the they are to be seen at various places from the latitude of Arctic regions, and it seems reasonable to suppose that

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[1] Dr. Holl, Quart. Journ. Geol. Soc., vol. xxi.

[2] Harkness and Hicks, Quart. Journ. Geol. Soc., vol. xxvii.

[3] Carl Pettersen, Geol. Mag., Sept. 1875.

tions indicate parts only of what were probably two great continents extending over these areas, separated from one another by an intermediate ocean, narrower considerably than the present Atlantic, but still occupying part of the basin. When these continents commenced to subside, the parts facing the Atlantic were the first to become submerged. On the European side this is evident from a consideration of the sediments, and also in the faunas (of which I shall have to speak more fully in another part of the paper); and it seems tolerably clear that such was also the case on the American side. I have attempted to explain in another paper[1] the lines of depression along which the waters gradually encroached, and endeavoured there to show that the contraction must at this time have taken place along two well-defined lines, or that the continents, before they began to subside, had for the most part a sloping surface with the higher plateaux to the north-east on the European, and to the north-west on the American side. As also at a later period in the Palæozoic age parts of these old continents were above water-level, when contiguous areas were submerged to a great depth, it is evident that they were traversed by mountainous ranges of great height. Some portions of this old land now visible to us in Western Europe were undoubtedly brought up to the surface from a very great depth at the close of the Palæozoic, whilst others, upon equally certain evidence, could not have been but at a slight depth at that time, and some probably not even then submerged. This condition of continents of great size in high latitudes, with elevated plateaux and high mountains, would lead us to believe that they were covered with ice and snow in their higher parts, and that the plains and valleys had therefore much loose material strewn over them. In the Cambrian rocks in Wales boulders of considerable size, sometimes a foot in diameter, are often found in the beds of conglomerate, and the frequent alternations of conglomerates, grits and sandstones, seem to prove that, at least in the earlier epochs, an abundance of loose material must have been near and ready at hand to be easily denuded off as each part became submerged. Marine action on the hard metamorphic cliffs alone could scarcely have produced so much sediment. Moreover, the enormous thickness found with scarcely a trace of any beds heaped up by marine life at this period, either in the American or European areas, as may be seen by reference to the Table, show conclusively that an additional force must have been at work. In some places, also, the sediments were heaped up so rapidly, that during a depression of several thousand feet the rate seems only to have kept pace with the accumulations, and shoal conditions continued to prevail during the whole time. As the depression went on, the areas first submerged received only such materials as could be carried a considerable distance, and hence finer deposits are found over these, whilst in the more immediate regions of the still unsubmerged lands, the rougher materials continued to be heaped up. We find, therefore, contemporaneous deposits formed to some extent of very different materials, and varying considerably in thickness. After the close of the Cambrian, marine life helped in making up the formations in nearly all the areas, and in some cases, as may be seen on referring to the Folding Table, to build them up almost entirely. By the close of the Lower Silurian, the pre-Cambrian crust had been depressed along the south-western borders of Europe to a depth of over 30,000 feet, and sediments to that extent had in some cases been heaped up. Along the eastern borders of North America sediments had also accumulated to a depth of over 18,000 feet,[1] so the depression there must also have been great. Over other areas the sediments were comparatively thin, and the crust at those parts but slightly submerged. In many of these places the faunas also are such as would indicate only a moderately shallow sea. In some parts in Asia, in America, and also in Europe, the higher points of the pre-Cambrian ridges were still above the water-level. Hence it is evident that the series up to this time must have varied greatly in thickness, and generally in proportion to the unevenness of the pre-Cambrian crust. In Lower Silurian time, volcanic action took place over limited areas, and the sediments at those parts were greatly added to by the ejectamenta, and therefore heaped up rapidly. In Great Britain, and the south-west of Europe, and also in the neighbourhood of Lake Superior[2] in North America, the Lower Silurian rocks are made up in part from volcanic materials, as tuff or contemporaneous trap, and ashes re-arranged by water. The volcanos, which at first appear to have been entirely submarine, had heaped up, before the close of the Lower Silurian, by repeated eruptions in the British areas of North Wales and Cumberland, sufficient material to reach in some places considerably out of the water, and hence to form islands. During the later period of these eruptions, certain movements terminating in the elevation of portions of the earth's crust took place also over limited areas in Western Europe and in North America. In Western Europe these movements seem to have been confined to the immediate regions of volcanic action, but in North America they were apparently unaccompanied by any direct outbursts, though the uplifted portions show indications that the sediments had been subjected to the influence of great heat;[3] greater in my opinion than what could be produced by contortion and upheaval only, if the evidence in other rocks which have undergone contortions only can be relied on. This break, the first in the Palæozoic rocks, is entirely confined to portions of the areas first submerged and usually to the deeper parts, and where the greatest thickness of sediment had accumulated on the Pre-Cambrian crust. Immediately after these movements had taken place, depression seems to have gone on again over those areas, and parts which had been raised above the water were once more covered by the sea, and sediments thrown down upon them. It will be seen, therefore, that these breaks are not signs that there was an arrest in the subsidence generally over even these areas. Over the larger areas, it is certain that the contraction of the crust at this period continued go on uninterruptedly, and the sediments show perfect conformlity there at this point. Even in the British area, the breaks re restricted to narrow limits, and beyond these limits the sedints accumulated regularly, and each epoch is there fully repreted. An unconformity over a small area is no evidence, there-, of a want of continuity in the greater changes that were taking ce, and its presence is no criterion that there was at that time a eral arrest in the subsidence, and hence in the contraction of the st throughout the larger part of the Northern Hemisphere. In classification of the rocks, such a line, however, is useful, and as an be recognized in more than one district in Europe, and in th America, it forms a good boundary-line between the Lower Upper Silurian. The line of demarcation has hitherto been ced by authors in very various positions and generally in accorde with what has been observed by them in the places under their ervation.

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[1] Quart. Journ. Geol. Soc., Nov. 1875.

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[1] H. D. Rogers, Dana, etc.

[2] Foster, Whitney, Owen, etc.

[3] Green Mountain Region, Logan, according to Dana, Hunt, etc.

or present purposes I propose to retain the line adopted by the Sir Charles Lyell,[1] and hence to include the Lower Llandovery he Upper Silurian. Another reason for doing this is the tolerable versality over the British area of a band of limestone at the close the Bala period, and which seems to have been formed just before uplifting took place. It is known in parts of Wales as the Hirnant nestone, in Shropshire as the Caradoc Limestone, in Cumberland the Coniston Limestone, and in Scotland as the Wrae Limestone, we have here a good line formed, and over considerable areas. some of the undisturbed regions in Europe and in America the nation of limestone which commenced early in the Lower irian continued to go on uninterruptedly at its close, and there lged over and connected it with the Upper Silurian so closely that doubt can arise as to the continuation of similar general conons throughout the greater part of these two epochs in those as. In Britain limestone beds of any importance are first found the Llandeilo Epoch, and were it not for the frequent spreading of the volcanic material over the sea-bottom, there can be no bt that the Lower Silurian period, like that in America, would re be represented chiefly by limestone formations. At present y occur at invervals in the series, and they show evidence of ing been deposited only during quiet periods intervening between more active eruptions. These limestones were doubtless formed irely by marine life, and in many places they are now exceedingly h in fossils. A quiet period consequently would be required for building up of any considerable thickness, and as they are now kest the farther removed they are from the disturbed areas, it is dent that the interruptions were due to the life being suddenly troyed or checked, and from being covered over also by an excess material thrown out over the sea-bottom. It is probable also that ere some of these formations were built up, a barrier in the shape

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[1] Prof. Hughes also recognized this line as being preferable to the one at the base the Upper Llandovery, and makes this the boundary between Cambrian and rian.

[illegible] ridges separated the area from [illegible] were active, so that in [illegible] on one side, whilst it [illegible] diversities in thickness [illegible] may be shown even within [illegible] these ridges still existed [illegible] or north-western [illegible] there is ample proof to show, [illegible] considerable size formed [illegible] at this time. Speaking generally [illegible] Cambrian and Lower Silurian [illegible] of great size occupied [illegible] traversed by mountainous [illegible] took place generally from [illegible] more decidedly along [illegible] north-east in Europe, and from [illegible] North America, that the sediments over [illegible] conditions at first and of being [illegible] afterwards of having been heaped up [illegible] where volcanic material jointly assisted in forming them.

([illegible])

IV.—On Cretaceous Gastropoda (Scalariform Shells).

By J. Starkie Gardner, F.G.S.

([illegible])

THE remaining shells figured on Plate IV. do not belong to the [illegible], but to families considerably removed. The form next described undoubtedly belongs to the family of Aporrhaidæ, the rest are [illegible].

In my preceding paper on Aporrhaidæ, Geol. Mag. Dec. II. Vol. II. page [illegible], I distributed the species I had described into four genera. I was unable to assign the shell I am about to describe to any of the genera then constituted, and therefore left it undescribed, hoping that time might throw some additional light on its affinities. No additional information, however, has been forthcoming, and no second specimen has been found at Folkestone. Through the kindness of Mr. Jukes-Browne, I have, however, received two specimens from Cambridge; he has also compared my Folkestone specimen with that originally figured by Seeley as Sc. *angularis*, and I no longer feel justified in delaying to add this singular form to those I have already made known. The character of the outer lip and last whorl is so peculiar as to preclude this shell from being placed in any one of the genera already formed, and I therefore propose a new sub-genus to receive it—

Brachystoma, J. S. G.

Shell turreted, elongated; whorls ribbed; last whorl angulated, [illegible]; outer lip thin and turned slightly inwards, projecting beyond the spiral angle; mouth angular.

BRACHYSTOMA ANGULARIS, Seeley. Gault. Plate IV. Figs. 11 & 11*a*.

Shell elongated, angle 24°; whorls ten or eleven, elevated, moderately convex; apex smooth, not acuminated. Ribs twelve, nearly straight, prominent, rounded; sutural region flat, strongly striated; striæ rounded and undulating, not angulated, crossed by fine lines of growth. The last whorl is angulated and projects beyond the spiral angle; the ribs are absent on the dorsal side near the aperture, and are replaced by lines of growth; it also possesses two slight keels, the anterior being but faintly marked. The mouth is sub-pentagonal. The cast is distinctly ribbed and preserves traces of striæ, the last whorl being smooth, but with remains of the keels.

This species is readily distinguished from all others of the Gault by the greater height of the whorls. The wing process is so very reduced that the shell might be taken for a *Scalaria;* but the change in character of the last whorl leaves no doubt that it is a true *Aporrhaïs*, to which genus indeed Pictet and Campiche had already noticed its resemblance.

Seeley describes this species in the Ann. and Mag. of Nat. Hist. for April, 1861, p. 6, pl. xi. fig. 9, as *Scalaria angularis*, from a specimen belonging to Mr. Carter, of Cambridge.

Family RISSOIDÆ, Forbes and Hanley.

No true *Rissoa* appears hitherto to have been found in British Cretaceous rocks, although a few species have been described on the Continent.

The *Rissoidæ* were separated from Lamarck's family of *Littorinidæ*; since, they have been classified by Schwartz von Mohrenstein, Deshayes, Adams, W. Stimpson, and others, and the family has been divided into as many as seven sub-families and 43 genera, of which only one is now brought under notice.

The *Rissoidæ* are of especial interest, on account of the gradual transitions found amongst them from aquatic to terrestrial forms. The marine species, however, usually possess a strong, solid shell, and are ornamented with striæ or ribs; the brackish-water forms have a thinner shell; whilst the shell of the fresh-water and amphibious species is generally thin and smooth.

RISSOINA,

was proposed as a sub-genus, by d'Orbigny, of the mollusca found during his voyage in South America, and later erected into a genus in consideration of the operculum, the muscular impression of which has an elongated process. It is adopted by most classifiers. Schwartz von Mohrenstein[1] has published a monograph on *Rissoina*, in which is enumerated 91 species, 29 being fossil. Deshayes accepts the genus with hesitation, but gives a minute description of its characters.

The *Rissoina* are small marine mollusca, which live on algæ in shallow water and in warm latitudes. They are particularly distinguished by the form of their aperture, which is oval, crescentic, narrowed posteriorly, the lips uniting on the penultimate whorl; it is dilated in front, so that the extremity projects beyond the columella. The aperture is oblique to the axis, towards which the front is inclined; the outer lip is very much thickened, the thick edge being sinuous; it is sometimes terminated anteriorly by a slight, narrow and shallow groove, whilst in a few species the front edge forms a gradual curve, the point of demarcation being scarcely visible, passing thus insensibly into *Rissoa*. The figure represents the mouth of *R. Sowerbii*, which may be considered typical of the genus.

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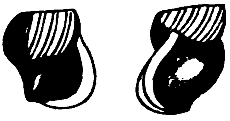
[1] Denkschriften d. k. Akad. d. Wissensch.-Mathem., 1860, vol 19.



Mouth of *Rissoina Sowerbii.*

H. A. Adams thus defines the genus :[1]—"Shell turreted, ribbed or cancellated, many-whorled; spire acuminate; aperture ovate, effuse anteriorly, slightly channelled in front; outer lip anteriorly dilated, thickened internally."

Rissoina first appears in the Jurassic rocks; in the Cretaceous era the species are few, only three being described; of these, but one is British; a fourth is here added for the first time.

RISSOINA INCERTA, d'Orb. Gault, Folkestone. Plate IV. Figs. 12 and 13.

Shell elongated, angle of spire, exclusive of projected lip, 20°; whorls slightly rounded, smooth, without trace of ornamentation, sutures distinct; mouth ovate, outer lip inflected and dilated, very much thickened, slightly channelled anteriorly. The surface of the shell, when highly magnified, exhibits an irregularly wavy striated appearance, somewhat similar to the bark of trees (Fig. 13*a*). This species was first described by Deshayes as *Melania incerta*, 1841, Mém. de la Soc. Géol., t. 4, p. 320, and again by d'Orbigny, Pal. Fr. p. 62, pl. 155, fig. 11-13, and by Schwartz von Mohrenstein, in his Monograph, 1860, tab. xi. f. 89. D'Orbigny's figure presents a smaller angle than that of our specimen.

It is not a very uncommon shell, being found in a beautiful state of preservation in the Gault of Folkestone. The shell, when the last whorl is not present, resembles and has been described as a *Eulima*.

RISSOINA SOWERBII, J.S.G. Gault of Folkestone.
Plate IV. Figs. 14 and 15.

Shell elongated, angle of spire, exclusive of last whorl, 20°: whorls ten, inflated, transversely and obliquely ribbed, the ribs, extending to the sutures, without striæ; sutures distinct; mouth ovate, outer lip inflected and dilated, very much thickened, slightly channelled anteriorly. Last whorl without ribs dorsally.

Sowerby figured this shell in the Trans. Geol. Soc., vol. iv. pl. xi. fig. 17, as *Rostellaria buccinoides*. He remarks that the shell has but one varix, by which he probably intended to signify the thickening of the mouth, as the shell is not subject to varices.

R. Sowerbii strongly resembles the last species in general form, but is ribbed. It is abundant at Folkestone, but has hitherto been

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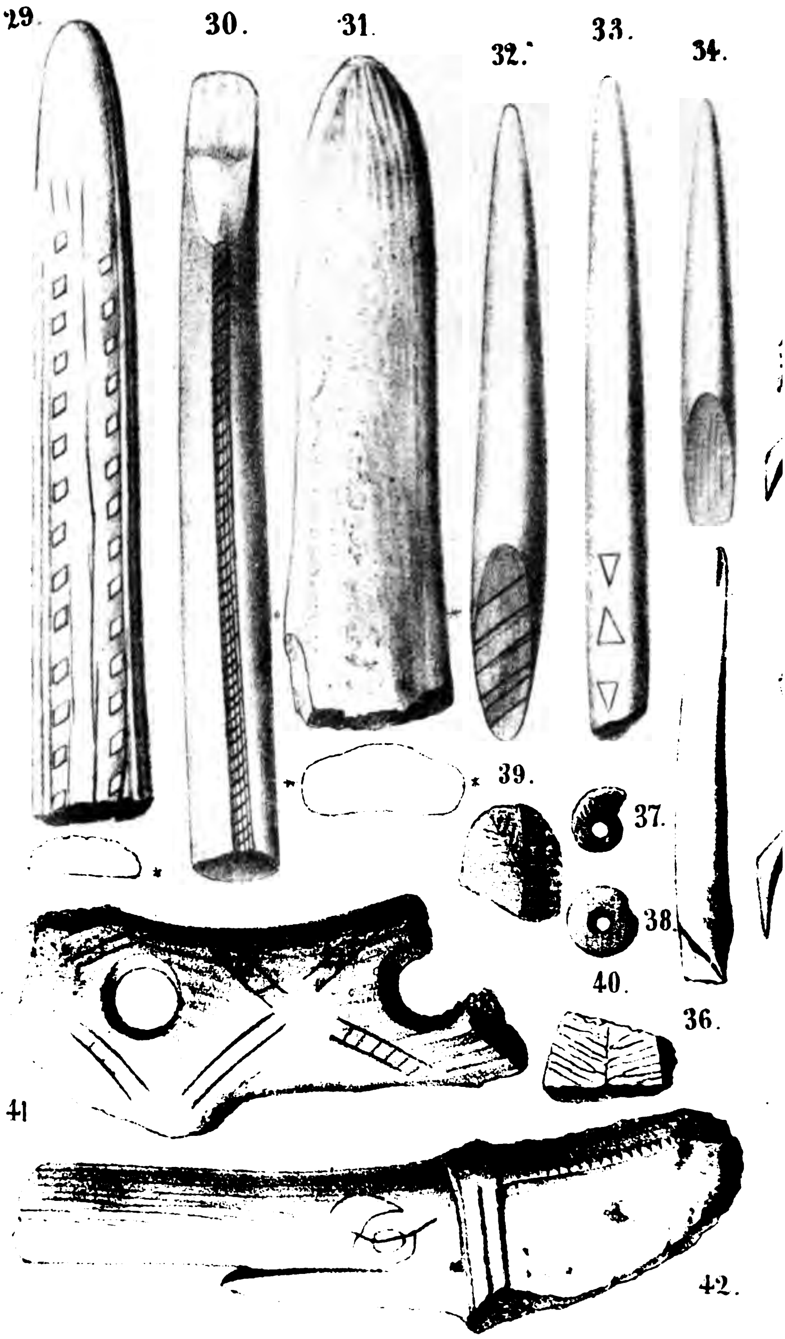
[1] Adams, Genera of the Mollusca, vol. i. p. 327.



ons of Bone etc., Kesslerloch Ca

istaken for *Scalaria Gastyna*, on account of a resemblance to Orbigny's figure of that form. I have, however, had an opportu-ty of comparing the actual specimens in d'Orbigny's collection at e Jardin des Plantes, and find that his species is a true *Scalaria*, id attains considerably larger dimensions than does *Rissoina*.

The genus *Keilostoma* of Deshayes is found in the Cretaceous rocks India.

REVIEWS.

XCAVATIONS AT THE KESSLERLOCH NEAR THAYNGEN, SWITZERLAND; A CAVE OF THE REINDEER PERIOD. By CONRAD MERK. Translated by JOHN EDWARD LEE, F.S.A., F.G.S. 8vo., pp. 76, Frontispiece and 15 Plates. (London: Longmans and Co., 1875.)

(PLATE V.)

THE student of prehistoric archæology in Britain is deeply indebted to Mr. John Edward Lee for his valuable contributions to our literature in this department. His translation of "Keller's Lake Dwellings of Switzerland" was of the greatest utility here in England, and enabled many to realize the vast store of relics which Keller and his countrymen had brought to light, bearing upon the early condition of these Lacustrine peoples.

The present work is a translation of Conrad Merk's account of the result of excavations at the Kesslerloch Cave, near Thayngen, Canton Schaffhausen, and introduces us to a cave of the "Reindeer Period," which in its buried relics forcibly reminds us of the Belgian caves, and of the cavern of Bruniquel on the Aveyron, and those of the Vezere described by Messrs. Lartet and Christy in the *Reliquiæ Aquitanicæ*,[1] so ably edited by Prof. T. Rupert Jones, F.R.S.

Mr. Merk, the discoverer and explorer of this cave, was for some time the Government teacher of practical science at Thayngen, and has evinced an amount of acumen and research in carrying out this work which deserve the highest credit. The Schaffhausen Natural History Society, under advice of its able President, Dr. Von Mandach, undertook the whole expense of the exploration. Half the collection gathered was sold by the discoverer to the Museum of Constance, the other half remains in the Museum of Schaffhausen.

Mr. Lee, who examined the collection at Schaffhausen in company with Mr. A. W. Franks, F.R.S., Keeper of the Ethnological Collections in the British Museum, is able to testify to the genuineness nd excellence of the relics. With the exception of two incised rawings on bone (found afterwards by a workman in the heap of ubbish left after sifting by Mr. Merk), a doubt even has not been cast pon any of the remains. The series of layers composing the cave eposits occurred in the following order: The UPPERMOST BED, arying in thickness from 47 to 55 inches near the mouth of the cave, 41 inches near the middle, and 3½ inches in the further northern hamber, is composed of angular fragments of White Jura Limestone,

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[1] This fine work is just completed (see GEOL. MAG., Dec. 1875, p. 610), and may obtained from the publishers, *Williams & Norgate*.

mixed with disintegrated rock and surface rubbish. It was nec
sary to remove 4,300 cubic feet of this uppermost layer, or ab
170 tons. Beneath this rubbish-bed a layer of Stalagmite was n
with, from 12 to 20 inches in thickness. The Stalagmite was
hard that it had to be blasted with gunpowder in order to remove

Numbers of bones and a few flint flakes were found adhering
the underside of the Stalagmite floor. Beneath the Stalagmite a
rubbish-layer followed the relic-bed, a layer of black earth made
chiefly of a mass of fragments of bones of various animals, togetl
with hearth-stuff, flint flakes, and the remains of weapons and on
ments in bone and horn, so characteristic of the Cave-folk of t
Reindeer Period. This bed was found to be 15 inches thick
front of the Cave, in centre 11 inches, and at the back part on
4 inches. This bed also extends considerably in front of the Ca
deep down under the present surface, marking the waste of the lin
stone and the rate of accumulation of *debris* outside the Cave.

Below the black relic-bed, and extending over the whole floor
the Cave, another bed was met with coloured red with peroxide
iron, and also containing bones and implements in a matrix of coi
minuted limestone. This bed varied in thickness from 14 to
inches. Beneath the red bed was a regular bed of yellow loam, t
depth of which has not been fully ascertained. No implements
bones were discovered in this bed, although some few bones ai
implements, and also some flint flakes, lay pressed into it, provi
that, in this case, man was the first occupier of the Cave.

Each layer was carefully removed by Mr. Merk, and its conten
kept perfectly distinct from the other, and submitted to Profess
Rütimeyer; but although differing markedly in colour and conditio
the bones from the two layers do not prove in any way distin
We have, then, in this Cave *but one period* represented, althou
it was a place of lengthened occupation. The cubical contents
the red and black layers removed amounted to nearly 3,530 cub
feet. About one ton and a half weight of bones was extracted fro
the cave-earth. Every bone which contained marrow had, as usua
been broken in pieces; indeed, no entire bones of any kind appe
to have been met with. At least 90 per cent. of the bones foun
belonged to the Reindeer; they afford evidence of about 200 adu
Reindeer and 50 young ones slaughtered for food by this one Cav
family. Remains of about twenty Horses, of six great Red Dee
probably as large as the Wapiti (*Cervus Canadensis*), were also foun
together with fragmentary evidence of *Bos primigenius*, of *Bisc*
priscus, and two phalangeal bones referred to the "Marsh-Cow
(similar to that met with in the Swiss lake-dwellings). With thes
have also been found the Ibex and Chamois. A considerable numbe
of bones of the Mammoth (*Elephas primigenius*) have been foun
including several portions of skulls and various bones of youn
animals of different ages, phalanges of adult elephants and a larg
number of broken fragments of great bones. Most of these Mammotl
bones come from the *lower* (red) *relic-bed*, some resting immediatel
on the clay, and some were coated with stalagmite. But two molar

nd a tusk were found in the black bed, together with many fragments of tusk. The tusk was only 2½ inches below the black band, nd is 53 inches long, and weighs 42 pounds; but owing to its friability (and probably to a want of knowledge of the process of gelatinizing such relics), it fell to pieces.

The Cave of Kesslerloch also furnished some fragmentary remains of *Rhinoceros tichorhinus*, probably an old animal; 17 Wolves, 80 Foxes, 1 Wild Cat, 4 Lynxes; some fragmentary remains of the Cave-lion (*Felis spelæa*), 4 Gluttons, 2 or 3 Bears (*Ursus arctos*), 1 Marmot, and more than 500 Alpine Hares which had been eaten n this cave. About 80 Ptarmigan, a wild Goose, a wild Swan, he Raven, a Sea Eagle, etc., make up the bill of fare of these old Cave-folks.

Although the weapons agree in character with those of the Belgian nd French caves (see Plate V.), and the incised drawings of nimals are not a new discovery in these prehistoric retreats, yet, nevertheless, we fully agree with the translator (Mr. J. E. Lee) in he opinion that the dwellers in the Kesslerloch Cave had attained to a degree of excellence in their engraving of animals superior to that of the dwellers in Aquitania.

In support of this view, we would refer our readers to the life-ike representation of a Reindeer found in this Cave engraved upon a portion of the beam of a horn of that species, which we reproduced in the GEOLOGICAL MAGAZINE for December, 1875, Pl. XV. p. 610. We cannot help placing this example in the first class among prehistoric engravings. As to the two doubtful drawings from this Cave (given on pl. xv. figs. 98 and 99), we should feel much hesitation in vouching for their genuineness, and cannot but ecall the familiar *Renard* of our fable-book, and the equally friendly ace of *Bruin* in search of honey, or performing in our market-place.

Mr. Conrad Merk deserves the highest praise for his work. The Cave is one of no small interest, as bringing together the Reindeer nd Mammoth Periods, and showing, as we have elsewhere maintained, that there were no hardly-defined boundaries between any of these, but that just as the Palæolithic, the Neolithic, the Bronze, and he Iron ages shaded into each other, or existed side by side, so the periods of the Mammoth, of the Reindeer, and of the modern Fauna, have passed imperceptibly, and by slow gradations, over Western Europe, some forms dying out, as the Mammoth and Rhinoceros; others migrating north, as the Reindeer; others again passing slowly under the domination of man, as the Horse and the Ox; whilst the Bison and Red Deer are gradually becoming exterminated by the descendants of Nimrod, whose weapons are a thousand times more deadly than those of the hunters of the Kesslerloch.

EXPLANATION OF PLATE V.

(This is "PLATE VII." in Mr. Lee's English Edition.)

Articles of ornament and weapons of the chase from the Cave of the Kesslerloch, ear Thayngen, Schaffhausen, Switzerland:

FIG. 29.—Ornamental scraper (see p. 40 of Mr. Lee's book).
„ 30.—Ornamented spear-head (p. 37, op. cit.).

Fig. [illegible].—Scraper (p. 43, op. cit.).
" 32.—Arrow-head with notches (p. 38, op. cit.).
" 33.—Broken spear-head, ornamented (p. 38, op. cit.).
" 34.—Bone arrow-head (p. 38).
" 35.—Bone harpoon (p. 38).
" 36.—Broken spear, or arrow-head (p. 39).
" 37.—Perforated ornament (p. 40).
" 38, 39, 40.—Ornaments of stone (p. 41).
" 41.—Broken baton (?) with two perforations (p. 40).
" 42.—Ornamented bit of pointed (?) (p. 43).

II.—Guide to the Geology of London and the Neighbourhood. By W. Whitaker, B.A., F.G.S. Second Edition. (London, 1875.)

THE popularity of this excellent Guide to London Geology is fully proved by the fact that a second edition has been called for in less than three months from its publication. The only material difference between the two editions consists in the addition of a short paragraph at p. 3, explanatory of the section in the frontispiece, and of references to the Geological Survey Memoirs, where more detailed accounts of the sections, etc., are to be found. B. B. W.

III.—On the Geological Conditions affecting the Water Supply of Houses and Towns, with Special Reference to the Modes of Supplying Oxford. By J. Prestwich, M.A., F.R.S., etc. (Oxford: Parker & Co.)

WATER-SUPPLY in relation to geological structure of a district is a subject to which Prof. Prestwich has paid considerable attention. His work, "The Water-bearing Strata of the Country around London," published some years since (1851), was the carefully considered result of much labour and experience derived from his geological investigations relating to the subject, with a view of affording to the metropolis a larger and purer supply of water; and that practical knowledge rendered him an efficient member of the Royal Commission on Water-Supply of 1866. In this lecture, the subject is continued in relation to the water-supply of Oxford, and, after some general but interesting observations, the author alludes to the former supply from the river, and the present supply from the valley gravel, and its sanitary bearing; and then proceeds to indicate other sources of supply dependent on the geological conditions of the surrounding country, which are fully discussed, as well as the quality of the water likely to be obtained. From this, it appears that the various sources for a better supply to Oxford are—the water in the gravel beneath the alluvial deposits of the Isis, taken above Oxford,—by an artesian well north of Oxford, by springs in the Chalk and Oolites, as well as from wells in the same formations, both of which would yield an abundant and excellent water; the only objection to the latter two sources being their distance from Oxford. We cordially recommend the perusal of this lecture not only to the inhabitants of Oxford, but the general reader, and to those interested in taking precautionary measures for preventing the pollution of water supply. It is accompanied with a neat hydro-geological map, plan and sections relating to the geology and water-supply of Oxford, which was the real object of the lecture. Still the subject is treated in a sufficiently general manner to be equally applicable to other towns, villages, and mansions, similarly situated geologically, and where contamination of water must probably occur, as shown in the diagram (figs. 1 and 2), where surface wells exist in close proximity to the drainage of cesspits and other impure sources. "At the same time," says the author, "however practical the question of water-supply may be in one aspect, the knowledge of the underground distribution of water is, in its other bearings, not less essential to the theoretical geologist."

J. M.

IV.—The Geological Record for 1874: an Account of Works on Geology, Mineralogy, and Palæontology, published during the Year. Edited by William Whitaker, B.A., F.G.S., of the Geological Survey of England. 8vo. pp. 414. (London: Taylor & Francis, 1875.)

ENCOURAGED by the success which has attended the "Zoological Record,"[1] and urged on by the growing necessity felt by geologists for some concise and handy book of ready reference for the convenience of English students, such as German and French scientific men have long enjoyed,[2] a small band of disinterested and earnest workers in geology, palæontology and mineralogy united together in 1874, and, aided by a list of guarantors (whose function has happily been a purely honorary one), they have issued to subscribers of 10*s.* 6*d.* a neat and clearly-printed large 8vo. volume of 414 pages of well-arranged matter, containing a brief summary of more than 2,000 papers for 1874.

The general editor is Mr. William Whitaker, who is an old soldier at such tasks (having himself, single-handed, compiled and published some most useful lists of works relating to special districts, as well as being the author of several able Survey Memoirs).[3]

Mr. Whitaker is supported by Messrs. H. Bauerman, F. J. Bennett, W. Carruthers,° F. Drew,° C. E. De Rance, E. Erdmann, R. Etheridge, Jun.,° Walter Flight, C. Le Neve Foster, A. H. Green,° C. P. Gloyne, T. M. Hall, E. T. Hardman, F. W. Harmer, T. R. Jones, R. L. Jack, G. A. Lebour,° L. C. Miall,° H. Miller, E. T. Newton, H. A. Nicholson,° J. McPherson, F. W. Rudler,° F. Rutley, E. B. Tawney, W. Topley,* and H. B. Woodward.°

° Those marked with a * act as Sub-Editors.

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[1] The "Zoological Record" was commenced in 1865, and has now attained its tenth volume.

[2] The Neues Jahrbuch fur Mineralogie und Geologie was commenced in 1830; Poggendorff's Annalen was begun at Leipsic in 1799, and has reached 233 volumes; Delesse and De Lapparent's Révue de Géologie has reached 11 volumes.

[3] List and Supplement of Works on the Geology, etc., of Devonshire, 1870-72. Trans. Devon. Assoc. List of Works on the Geology of Cambridgeshire (Woodwardian Museum, 1873). The Geology of the London Basin (in part). Geology of Parts of Oxford and Berks (in part). Geology of S. Berks and N. Hants (in part), and Geology of Parts of Middlesex. *Guide to the* Geology of London, 2nd edit. 1875.

The "Record" is divided under the following heads, namely:—(1) Stratigraphical and Descriptive Geology, 160 pages; (2) Physical Geology, 25 pages; (3) Applied and Economic Geology, 10 pages; (4) Petrology, 24 pages; (5) Mineralogy, 40 pages; (6) Palæontology, 80 pages; (7) Maps and Sections, 10 pages; (8) Miscellaneous, etc., 28 pages. With an index of 19 pages.

On the average, there are as many as five abstracts to a page, but occasionally, where the subject-matter requires to be given in greater detail, they are more full.

It would be but a poor compliment to pay the Editor and his able staff, to say that the work is perfect; but as a first year's result it is highly satisfactory, and the general plan seems admirable, although we think the palæontological section might be classified in greater detail with advantage.

We shall look forward with pleasure to the appearance of vol. ii. for 1875, and cannot help prophesying a great increase both in its contents, and also in the number of its subscribers. Meantime, we would record our best thanks to the compilers and editor, for the manner in which they have carried out the work so far.

V.—The Dawn of Life; being the History of the Oldest Known Fossil Remains, and their Relations to Geological Time and to the Development of the Animal Kingdom. By J. W. Dawson, LL.D., F.R.S., F.G.S., etc. 8vo. pp. 239, 8 Plates and 49 Woodcuts. (London: Hodder & Stoughton, 1875.)

WE are all so fully aware of a grand uniformity of plan pervading creation, and of the limits of variety and modification in organic growth being far beyond our knowledge, that the naturalist regards any apparently strange unconformist in the ranks of the animal or the vegetable world as a subject of curiosity—that is, of inquiry and research, rather than of astonishment and blank wonder. So also the mineralogist and the chemist look on every newly-discovered substance coming under their notice as necessarily part and portion of the great but varied cosmical mass of matter, whether organic or inorganic. It cannot be really strange; it has its relationships and alliances; it falls into systematic order with this or that known group of things.

Thus prepared to recognize a wide range of analogies, similarities, and identities, the biologist and the mineralogist sooner or later work out the natures and alliances of the objects submitted to their examination more or less completely; and systematic knowledge, or science, increases.

It is rare indeed now-a-days that a question arises as to whether a material under examination be of organic or inorganic origin; but in the case of Sir William Logan's fossil known as *Eozoön Canadense* there are still such doubts felt and expressed; and to clear these up is the purpose of Dr. Dawson's book before us.

In the treatment of the vexed question whether *Eozoön* be a fossilized Foraminifer, or merely an arrangement of mineral substances more or less resembling foraminiferal structure, it appears that, as is natural, some observers, mineralogically inclined, lay great stress on the mineralogical analogies, similarities, and composition; while others, recognizing what they believe to be the inimitable, but petrified, structure of a Foraminifer, regard it as an organism. Further, the former think they know enough of Foraminiferæ to be able to deny that there is as much of the special structure as they are told is there; and, on the other hand, the foraminiferists, if geologists too, think they know enough of minerals to be able to weigh fairly any doubts in that direction. How like other discussions polemic, whether in politics or theology!

There are exceptions also to this grouping of the disputants; for not only do many professed mineralogists hesitate to claim *Eozoön* as wholly inorganic; but, on the contrary, at least one expert in Rhizopoda, as seen in his papers in the "Annals of Natural History," does not recognize a perfect representation of the Foraminifer in *Eozoön*.

In 1852, 1858, 1863, and subsequently, the late Sir W. Logan and his colleagues of the Geological Survey of Canada discovered in the Laurentian Serpentine-marble of the Grand Calumet, on the Ottawa, at Grenville and elsewhere (Petite Nation, Burgess, Tudor, and Madoc), specimens of a fossil form, externally like *Stromatopora* and *Stromatocerium*, but internally consisting of somewhat irregular layers of calcite and magnesian silicates, and, under Principal Dawson's and Dr. W. B. Carpenter's microscopes, showing an arrangement of constituent parts analogous to what is only found in the shell-tissue of some *Foraminifera*, such as *Calcarina, Nummulina*, and their allies, the cavities of the shell being occupied by the silicates, rarely by dolomite and even calcite, and still more rarely remaining empty. Sir W. Logan and Dr. Dawson defined the fossil as an organism consisting of a foraminiferal shell, or calcareous tubuliferous test, once inclosing numerous segments of sarcode (now replaced by silicates[1]), spreading out laterally and piled up vertically, as large sessile patches, about a square foot in extent, 5 or 6 inches thick, and containing microscopic tubes and tubules, mostly filled with loganite, etc. Accumulations of these cake-like patches make up large portions of the green and white marbles referred to, and have partaken of the mechanical and chemical disturbances and alterations which the limestone bands and the inclosing gneiss have undergone. Obscure traces of perhaps crinoidal fragments in the limestone, and the presence of graphite, apatite, and iron ore are regarded as indicative of the existence of organisms in the Laurentian seas; worm-tubes occur in associated rocks; and pebble-beds in the gneiss prove the every-day water-action which produced the now metamorphosed beds. The heaping-up of broken serpentinous and calcitic *Eozoön*, over and beyond the recognizable patches, was pointed out by Sir W. Logan as completing the conditions of these Foraminiferal reefs of the period, and Dr. Dawson alludes to the outspread fragments of *Eozoön* in the rock far away from the reef.

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[1] White pyroxene, pale grey serpentine, loganite (a dark green alumino-magnesian silicate, allied to chlorite and pyrosclerite in composition, but differing in structure), pyrallolite and rensselorite.

Dr. Dawson in his "Dawn of Life" gives the details of the history of this discovery, together with an account of the Laurentian rocks; and, reprinting the papers and memoirs by Logan, Hunt, and others, treating of these matters, he points out the new localities for *Eozoön*, and additional facts illustrating its structure, especially due to careful and reiterated examinations by Dr. Carpenter. Dr. Dawson recognizes *E. Canadense*, with its varieties *minor* and *acervulina*, besides *E. Bavaricum*, of Gümbel. Objections (treated of in Chapter VII.) have been raised to the notion of the said laminated serpentine-limestone of Canada containing traces of organic structure; and the granules, threads, brushes, and filaments of magnesian silicates, which are construed by Dawson and Carpenter as infillings of foraminiferal chambers, passages, canals, and tubules, traversing a calcareous test, have been regarded as deposits, metamorphs, or pseudomorphs of the silicates and limestone, like some apparently analogous mineral formations, such as various segregations and concretions, dendritic, coralloid, laminated, filamentous, etc.[1] Both of these kinds of mineral arrangement, one due primarily to organic, and the other to purely inorganic processes, probably exist in such serpentinous limestones as those referred to, just as both mineral dendrites and real Conferval organisms exist in Indian chalcedonies; and as both creeping oxides and real Sponge-tissue are severally recognizable in flint. For the particular Canadian limestone under notice, the acceptation of a foraminiferal shell, quite within the zoological limits of known Rhizopodal life, and affected by mineral infiltration, similar to the glauconitic infillings of the shells and skeletons of various recent and fossil organisms, seems to be a natural explanation for the phenomena to be accounted for.

It has been remarked that *Eozoön* occurs only in metamorphosed rocks, whether in America or Europe, and therefore must be a product of metamorphism; but it is replied that it is a fossil peculiar to such very old rocks as have happened to be subject to metamorphic agencies from their position. We may add that perhaps some of the green grains in the soft unaltered old Silurian clays of Russia may be Eozoönal; and some of those figured by Ehrenberg have such an appearance.

Principal Dawson has brought together his own and Dr. Carpenter's observations on the structure of *Eozoön*, whether silicated or not,—for in some instances the calcitic layers remained channelled and perforated without any infillings, though difficult to be rightly seen except by an expert, and only with a high-class microscope. That the magnesian silicates of the *Eozoön* are analogous to the glauconite of other infiltrated organisms is denied by some; but, whether an infiltration into empty cavities, or a replacement of animal matter, or an altered mud or ooze, already pressed into chambers and tubes, it still appears to be analogous to the not very different glauconitic[1] infillings of pores and hollows in Echinodermatal, Coralline, Foraminiferal, and Polyzoan tissues, and even of minute Molluscan shells, as known in both recent and fossil specimens.

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[1] Some very curious minute imitative forms presented by coke are figured and described in the Phil. Mag. for January, 1876, by Mr. E. T. Newton, F.G.S. We might be disposed at first sight to set them in rivalry to some of the Eozoic structures; but the encrinitoid, zoophytoid, plumoid, and other forms of the coke do not reach such an exact state of similitude, much less do they all so definitely represent parts of one structure, as to support the idea of their being analogues of the particular serpentinous *Eozoönal* bodies above referred to.

Other objections have been made to the supposed Foraminiferal structure itself, particularly to the asserted presence of the primary, tubuliferous, "nummuline" layer, or "proper wall" of the test on both the upper and the lower surface of each successive segment of sarcode, such as is exhibited in Dr. Dawson's diagram, pl. 4, p. 58, and in the drawings at p. 176. Traces, however, of such an enveloping primary layer, on the lower face of the segments, lying on the preceding whorl of a discoid Foraminifer (as well as on the upper or outer surface, and on the front and back, where it makes the septa), is visible in both Dr. Carpenter's and Mr. Carter's horizontal section of *Operculina arabica*, cut a little out of the median plane.[2]

Dr. Dawson takes care to show that *Eozoön* is not without its Rhizopodal allies, and even associates. He finds in the Laurentian limestones numerous isolated little bodies (*Archæosphærinæ*), either single, beaded, or heaped (like *Globigerina*), which he regards as having been simple *Foraminifera* with tubulated walls (figs. 18 and 34, pp. 67 and 138), but whether immature forms of *Eozoön*, or quite distinct, he does not decide. He especially dwells on the existence of old Cambrian and Silurian Rhizopods, of large size, such as the *Archæocyathus*, *Stromatopora*, *Cannopora*, *Cœnostroma*, and *Receptaculites*. Of the last, Dr. C. Gumbel,[3] in 1875, published full particulars as to its Foraminiferal characters; Gustav Lindström[4] had already, in 1870, referred *Cœnostroma discoideum* (Lonsdale) to the Rhizopods; and Dr. Carpenter in 1867 ("Siluria," new ed. p. 547) expressed a decided opinion on the Rhizopodal structure of *Stromatopora striatella*. These points are not stated, however, by Dr. Dawson. That other Palæozoic *Foraminifera* occur, we well know. H. B. Brady's lately discovered *Archædiscus*, from the Carboniferous Limestone, referred to in a note at p. 164, is a Nummuline Foraminifer, of irregular growth, and to some extent represents an intermediate form between *Eozoön* and *Nummulina*. Indeed the last-mentioned, and its allies, *Fusulina* and *Amphistegina*, have also been found in the Carboniferous rocks, with many other *Foraminifera*, about to be described by Mr. H. B. Brady, F.R.S. The presence, therefore, of *Foraminifera* in the older rocks is not a matter of surprise, and the relatively large size of the individuals is no longer to be discredited, since *Parkeriæ* as large as small cannon-balls have bearing on these different subjects is also to be found in the paragraphs of the succeeding sections relating to the Parry ls, East Greenland, Arctic America, and such other lands as up to the present time been scientifically explored.

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[1] Hydrous alumino-magnesian silicates.

[2] Phil. Trans. 1859, pl. 4, fig. 5; and Ann. Nat. Hist., ser. 2, vol. x. pl. 4, fig. 5.

[3] Abhandl. K. bayer. Akad. Wiss. Clas. ii. vol. xii.

[4] K. Vet. Ak. Handl., vol. ix. No. 6, 1870.

it is to the geological portions of the "Arctic Manual" that we to draw particular attention; and for that purpose the subject be considered as a whole, without taking the information ded by the various sections in the order given in the book.

efore doing so, we must recall to recollection the situation of the rent localities subsequently referred to, to avoid misapprehension. fly then, between the 290 and 340 meridians of longitude, lies vast and almost unexplored tract of land known as Greenland, nding as far south as 60° north latitude. Of East Greenland nparatively little is known; but in West Greenland are several nish settlements, the most important being those at or near the land of Disco, situated in about 70° north latitude, which is sepated by a strait, called the Waigat, from the prominent Noursoak ninsula.

The arms of the sea known as Davis Strait, Baffin's Bay, Smith und, and Kennedy Channel, taken in order from south to north, parate Greenland from East Arctic America, Boothia, the Parry lands, etc.; while opposite the northern part of East Greenland are tuated Spitzbergen and Franz-Joseph-Land.

Greater difficulties lie in the way of the practical geologist in the inhospitable regions near the Pole than elsewhere, from the rarity with which the surface is free from snow, or good sections visible. But some important facts have nevertheless been ascertained, though there is much still to be learnt, both from a detailed examination of the fossil contents of the rocks, and as to the exact extent of the different formations known to exist.

Thus Cretaceous and Miocene fossils have been found in Greenland and Disco and described; Silurian rocks are known to exist in Boothia, Melville Island, and the neighbourhood; lastly, large areas of Basalt occur, and granitoid and metamorphosed rocks are to be seen nearly everywhere.

The western coast of Baffin's Bay abounds in gneiss, granites, syenites, and siliceous schists. The eastern coast from Cape Farewell, itself a granite island, to the north, consists of gneiss, alternating with granite and syenite. Mica-slate and hornblende-slate characterize all the mountain land; and Kingiktorsoak, one of the most elevated points in this extensive area, is composed of gneiss, against the lower part of which lie beds of mica-slate. This latter appears generally to overlie the gneiss, and all the lower mountains seem composed of it (Giesecké).

On the other or eastern coast of Greenland, the underlying rocks are known to be crystalline (Micaceous, etc.), and to be overlain by Basalts (Dolerites and Anamesites), and these re-occur in Spitzbergen and Franz-Joseph-Land. In the latter, "its broad horizontal sheets and the steep table-mountains, which recall the Ambas of Abyssinia, impart to the country its peculiar physiognomy," and the rocks to *the south resembled true Basalt* (Payer).

Thus underlying the entire area, and forming apparently the mountain ranges, as well as the whole of the interior of Greenland, are, as far as conjectured, a series of metamorphosed rocks, of probably more than one geological date.

Examining the rock-specimens more closely, the existence of Laurentian and Cambrian rocks among these is apparently indisputable. Thus at Upernavik, at Elwyn Inlet, at Navy-Board Inlet, and Port Leopold, in the Arctic American Archipelago, syenite occurs resembling the Laurentian series of Cape Wrath; whilst in South Greenland the syenite of the Kittisut Islands seems also to point to the presence of the Laurentian formation. The green felspar of the neighbourhood of Godthaab, the green compact felspar of Possession Bay and Cape Byam-Martin on the west side of Baffin's Bay, also indicate the presence of the Laurentian series. The Labrador felspar and graphite in the granite of South Greenland point probably to the same conclusion.

The Igalliko quartzite of West Greenland and some of the quartz-rocks of Upernavik, and of Elwyn Inlet, and other places in Boothia and the Arctic American Archipelago, "may be of the succeeding Cambrian age." This red compact quartzose sandstone of Igalliko Fjord, though "sometimes called Old Red Sandstone," has not yet been determined with confidence.

Some of the altered rocks, again, may prove to be referable to the Jurassics; for, on the west side of Baffin's Bay, "the jasper, siliceous schist, and chert resemble exactly those specimens which are found in the Isle of Skye among the beds of shale, sandstone, and limestone, which are known to belong to this geological era." Unaltered Jurassics have been identified in East Greenland, as brownish micaceous sandstones, with "a seam of bituminous fissile coal, associated with indistinct and indeterminable fragments of plants;" and further research may yet prove this series to be represented among the altered rocks of other parts of the region.

The Arctic Archipelago lying directly between North America and the Pole is the only locality in this region at present known where the Silurian rocks undoubtedly exist. Thus Melville Island, Beechey Island, and the shores of Wellington Strait, abound in fossiliferous limestone, in which Encrinites, *Favosites Gotlandica*, and *Halysites*, and other coralline forms are plentiful. "We may now then definitely colour the shores of Wellington Channel and Barrow Strait, except the eastern entrance of the latter (which is occupied by igneous or crystalline rocks), as Upper Silurian" (Salter). Boothia Felix also and the neighbouring localities have large areas covered by "dolomite or magnesian limestone in almost horizontal beds" (Haughton), and the numerous fossils these have furnished supply ample proof of their identity, and of the presence of Silurian rocks.

Here, however, occurs a marked gap in the chain of geological sequence; of the Devonian rocks "no clear evidence has been afforded, though we have heard of red and brownish sandstone, as observed in very many localities by various explorers, and which possibly may *belong to that formation*" (Murchison). This is, however, doubtful.

The Editor suggests in a foot-note already quoted that these may belong to the Cambrian series. But of the presence of still later groups we have ample and sufficient intelligence.

Banks Land, the northern portions of Eglinton, Melville, and Bathurst Islands, and all Byam-Martin Island are occupied by Carboniferous Sandstone, Limestone, Ironstone, and Coal. "True Carboniferous *Producti* and *Spiriferi* have been brought home by Belcher and others from Albert Land, north of Wellington Channel;" Mountain Limestone exists in Spitzbergen, of which we get the following details from Nordenskiöld:

1. Ryss Island, limestone, or rather dolomite, non-fossiliferous; traversed by beds of quartzite and flint. Thickness about 500 feet.
2. Cape Fanshawe strata, containing Corals. 1000 feet at the most in thickness.
3. Layers of hyperite.
4. Upper part of the Mountain Limestone, consisting of calcareous sandstone, limestone, gypsum, and flint, abounding in fossils, and 2000 feet in thickness. Between the strata are extensive seams of hyperite.
5. A very extensive and regular bed of hyperite, stretching from Mount Edlund to the Thousand Islands.

Mr. Salter has described *Fusulina hyperborea* (Grinnell Land), *Stylastræa inconferta* (Depôt Point), *Zaphrentis ovibos* (Princess Royal Island), and many others; and the Spitzbergen limestone abounds in characteristic fossils; but in Greenland proper no traces are at present known of true Carboniferous formations.

Jurassic (Lias) rocks and fossils were found by McClintock at Point Wilkie, on the eastern coast of Prince Patrick's Island, by Belcher at Exmouth Island, and by the German Expedition in East Greenland. To the latter reference has already been made, and the evidence afforded by species of *Modiola*, *Avicula*, *Nerita*, etc., is sufficient to fully identify it. In Spitzbergen, "shales, limstone, and sandstone, abounding in pyrites, and traversed by a small seam of hyperite," represent this formation; and at Mount Ardagh they give a thickness of 1200 feet. There are no other definite traces of this formation, unless the altered rocks, as before suggested, can be referred to it.

The succession of some younger rocks is less indefinite. In Spitzbergen, the Tertiary (Miocene) is represented by a fresh-water formation in Bell Sound, 1500 feet thick, consisting of conglomerates. shale, limestone, and sandstone, almost devoid of animal fossils, but containing coal-seams and fine impressions of plants. The Cretaceous strata are not described here; but it is possible that a more detailed examination might lead, as in West Greenland, to a further subdivision of these beds. A Tertiary coal-bearing sandstone has been observed in Franz-Joseph-Land.

The Expeditions that have produced the most satisfactory results in determining the nature of the fauna and flora of the Arctic Cretaceous and Miocene strata are those undertaken by Whymper and Brown in 1867, Nordenskiöld in 1870, and Steenstrup in 1874; when the Island of Disco and the Peninsula of Noursoak were carefully examined.

The general conclusions arrived at were these: 1. That Lower

Cretaceous beds containing numerous plant fossils (of which a copious list by Prof. Oswald Heer is furnished), and named the "Kome Formation," are found along the northern face of the Noursoak Peninsula at six different places. 2. That Upper Cretaceous beds (with, as Prof. Heer suggests, possibly Eocene plants in the top portion) exist on the south coast of the same land, and are named the "Atane Formation." 3. That surmounting the latter (further up the hill-side at Atanekerdluk) are Miocene beds.

Interspersed with, and superimposed on these in some places, are extensive beds of trap-rock, which form a singular and distinctive feature of the geology of the locality examined. "Sand and clay beds" are found lying between basaltic rocks at Sinnifik; at other places red basaltic clay lies between the strata; and Prof. Nordenskiöld, therefore, advances the opinion—that the eruptions which gave rise to these vast beds of basalt took place after the commencement of the Cretaceous, and ceased before the end of the Tertiary period.

The Cretaceous beds lying along the north coast of Noursoak (Kome, etc.), have among them (at Karsok) a remarkable layer of graphite, which, though exhibiting no organic remains, is probably, like the coal there, a member of the Upper series. The coal and the plant-bearing shales are interstratified with red and white sandstones, rarely fossiliferous; the fossils, which are preserved best in the lower strata, comprise numerous Ferns (*Gleicheniæ*), a fine Cycad (*Zamites arctica*), and numerous Conifers.

The Atane formation is rich in coal-beds, and has been assigned to the Upper Cretaceous (Heer), because of the frequent occurrence of Ferns, a Cycad (*Cycadites Dicksoni*), and a *Sequoia*; while the flora differs materially from that of Kome in the presence "of pretty numerous dicotyledonous plants, which are, moreover, quite unlike the Greenland Miocene plants." The upper strata at Atanekerdluk exhibit, at 1200 feet above the sea-level, a set of sandstones, shales, and hard ferruginous clays, rich in Miocene fossils; and the existence of tree-stools, with the roots branching out into the underlying clay-bed, affords evidence that the plants grew in the locality in which they are now found. The Miocene formation evidently extended over the Waigat Strait to the Island of Disco, at the south-east angle of which it attains its greatest thickness. But though thin seams of clay and coal are found here and there, coal-beds worth working are not likely to be discovered in this series. Dr. Brown is of opinion that no calcareous beds having yet been found in these Miocene strata, they are all of fresh-water origin.

The evidence of Cretaceous beds in the Island of Disco is not yet clear, though a specimen of *Caulopteris punctata* (Cretaceous according to Mr. Carruthers, F.R.S., and Prof. Heer) would seem to indicate that here, as elsewhere, they underlie the trap-rocks and Miocene strata. Over all lie the vast layers of trap-rock which give a peculiar character to the general appearance of Disco and the Waigat Strait. They appear to extend right across the country north of 69° north latitude, and in some cases are "not masses of lava, but consolidated s of volcanic sand, which in time, by pressure, have assumed a stalline character." They rest directly upon the gneiss, except on coast of Omenakfjord, Noursoak, and Disco, where they overlie sands and clays above referred to.

' It is possible this same formation may continue under the sea to land, and thence, partly in a more northerly direction, by Jan yen to Spitzbergen, partly in a southern direction from Jan Mayen, the Faroe Islands, to the Hebrides and Iceland, as between the eenland and British Basalt formations there seems to be, both in and character, considerable agreement."

Some remarkable facts have still to be referred to, viz.: the stence of quantities of wood, capable of being used for fuel, and ale-bones also, at high levels at many places, in gullies and ravines on hill-sides; and the enormous masses of meteoric iron which 'e also been discovered. The wood was believed by Sir Roderick rchison to be drift-wood, though the tree trunks from which the tions examined were sawn were many feet above the sea-level. existence of whale-bones at a distance above the sea-level has been n noticed. Their presence may arise from two causes,—either eaval of the land, or being placed as land-marks. In Spitzbergen number of bones lying together, belonging apparently to the e skeleton, and the "carcases and bones of whales at 80 or 500 elevation," would seem to indicate a gradual rising of the land; "in some cases vertebræ and skulls of whales have been set up landmarks," and these must not be confounded with the remains fted or left by retiring waters. The occurrence of a single skull bone, more especially on high or noticeable land, should rather assigned to the former cause than the latter.

The meteorites of Ovifak, one of which, now in the Hall of the yal Academy at Stockholm, weighed 19 tons, another at Copen- en 9 tons, and the third in the British Museum 195 lbs., were overed on the beach. They were strongly magnetic, and the extremely crystalline and brittle; but here and there "on their face, in the iron nearest the surface, pieces of basalt or fragments crust of basalt" were clearly visible, and this corresponded with material of the neighbouring rock. About 15 undoubted specimens were in all discovered by the Expedition of 1870.

n another locality, too, iron which Dr. Wollaston determined to be neteoric origin has been found. At Cape York, in Baffin's Bay, natives, as stated by Capt. Ross in 1819, had been accustomed se the metal for the edges of their knives, separating it from mass by a hard stone, and then beating it into small flat oval ces. "The place where the metal was found was called Sowal- , and was about 25 miles inland (Lat. 76° 12′ N.; Long 54° W.)."

But there is yet another discovery of considerable interest in con- ion with these regions. "Greenland is the only place in the rld in which the mineral Cryolite (valuable as a material whence minium can be obtained) has hitherto been found" (Tayler). Evigtok, on the shores of West Greenland, the widest seam 80 feet across; and the matrix (gneiss) is further enriched by numerous other minerals as well as copper- and iron-pyrites, while tin-ore in thin seams is extremely plentiful. The rigour of the climate and the difficulty of getting easy access to the country are the only obstacles to utilizing largely this source of wealth.

The physical changes in the country indicate that Greenland is still undergoing a comparatively rapid change. The south-western part is gradually sinking, and the northern portion rising; and no Aboriginal Greenlander (the western shores alone being now occupied) builds his house in modern times near the water's edge.

Numerous traces of old dwellings are now washed by the tide; and, as at the Moravian Colony of Fiskenæs, founded in 1758, "in 30 or 40 years they were obliged once, perhaps twice, to move the poles upon which they set their large boats, called 'umiak,' or women's boats. The old poles still remain as silent witnesses, but beneath the water." (Pingel.)

In Franz-Joseph-Land the same gradual upheaval has been noticed; and the raised beaches there, as well as the whale-bones of Spitzbergen, and those of North Cornwall, where (at Mount Parker) a skeleton is stated to have been found at an elevation of 500 feet, attest still further the great physical alteration that is going on in the Arctic Seas. Mr. Howorth's paper on Elevation of the Surface in the Arctic Regions, reprinted in part, pp. 483, etc., gives ample information on this subject.

It is difficult to foresee the effect of such a change of level. If the Franklin Archipelago does not share this movement, the final result may be that the narrow channel of Smith's Sound may become wider and deeper by the sinking of its East Coast, and thus afford easier access to that unknown area, to assist the explorers of which the "Manual" we have been examining has been compiled. In the future, the now often ice-blocked channel may be comparatively open, and the vast ice-cap of Greenland may extend towards the north-east, where the land would be slowly rising.

The final section of the work, Physics, by Prof. W. G. Adams, F.R.S., is as fully and exhaustively dealt with as that with which Geologists are more nearly connected; but the consideration of the branches of science with which it deals belongs to a province other than ours.

Not the least valuable part of the "Manual" is the Appendix, containing a list of the books already published on the question of Arctic research; and lastly a most excellent Index. With a volume containing so much and such varied information, the index is of the highest importance, and the care that has been bestowed on it enhances the value of the work under reference.

The "Manual," though produced in a limited time, and under great pressure, is a model of carefully compiled information up to the latest possible date; and the Royal Society may be congratulated on having furnished a most valuable contribution to scientific knowledge, and also in having entrusted the arrangement of the matter to such able and experienced hands as those of the Editor.

C. Cooper King.

REPORTS AND PROCEEDINGS.

Geological Society of London.—I.—February 2, 1876.—John Evans, Esq., F.R.S., President, in the Chair.

1. "Evidence of a Carnivorous Reptile (*Cynodrakon major*, Ow.) about the size of a Lion, with remarks thereon." By Prof. Owen, C.B., F.R.S., F.G.S., etc.

The specimens described by the author consist of the fore-part of the jaws and the left humerus of a reptile obtained from blocks of Triassic (?) rock from South Africa, forwarded by the late Mr. A. G. Bain, F.G.S. The upper jaw displays a pair of enormous canine teeth, much resembling those of *Machairodus*, being of a very compressed form, with the hinder trenchant margin minutely toothed. There is no dentated border to the fore-part of the crown. No teeth can be detected in the alveolar border of the right ramus of the lower jaw, which extends about an inch behind the upper canine. In the symphysial parts of the lower jaw the bases of eight incisors and of two canines are visible, the latter rising immediately in front of the upper ones, to which they are very inferior in size, and being separated by a diastema from the incisors. In this character, as in the number of incisors, the fossil resembles *Didelphys*; and in structure both canines and incisors resemble those of carnivorous mammals.

The left humerus is 10½ inches long, but is abraded at both extremities. It presents characters in the ridges for muscular attachment, in the provision for the rotation of the fore-arm, and in the presence of a strong bony bridge for the protection of the main artery and nerve of the fore-arm during the action of the muscles, which resemble those occurring in carnivorous mammals, and especially in the Felidæ, although these peculiarities are associated with others having no mammalian resemblances. The author discusses these characters in detail, and indicates that there is in the probably Triassic lacustrine deposits of South Africa a whole group of genera (*Galesaurus*, *Cynochampsa*, *Lycosaurus*, *Tigrisuchus*, *Cynosuchus*, *Nythosaurus*, *Scaloposaurus*, *Procolophon*, *Gorgonops*, and *Cynodrakon*), many of them represented by more than one species, all carnivorous, and presenting more or less mammalian analogies, for which he proposes to form a distinct order under the name of Theriodontia,—having the dentition of carnivorous type; the incisors defined by position, and divided from the molars by a large laniariform canine on each side of both jaws, the lower canine crossing in front of the upper; no ectopterygoids; the humerus with an entepicondylar foramen; and the digital formula of the forefoot, 2, 3. 3, 5; three phalanges.

The author further discussed in some detail the remarkable resemblances presented by these early Reptiles, in some parts of their organization, to Mammals, and referred to the broad questions opened out by their consideration. He inquired whether the transference of structures from the Reptilian to the Mammalian type has been a seeming one, due to accidental coincidence in species independently created, or whether it was real, consequent on the incoming of species by secondary law. In any case the lost Reptilian structures dealt with in the present paper are now manifested by quadrupeds with a higher condition of cerebral, circulatory, respiratory, and tegumentary systems, the acquisition of which, the author thought, is not intelligible on either the Lamarckian or Darwinian hypotheses.

2. "On the Occurrence of the Genus *Astrocrinites*, Austin, in the Scotch Carboniferous Limestone Series, with a Description of a New Species (*A.? Benniei*), and Remarks on the Genus." By R. Etheridge, Esq., jun., F.G.S.

The author, in his introduction to the paper, commenced with a general history of the genus *Astrocrinites* of Austin, commenting upon the change of name it had received from the several authors who had written upon and noticed the species *A. tetragonus* of Austin.

In 1843 Major T. Austin described this Aberrant Echinoderm under the name *Astrocrinites*, assigning its geological horizon to the Carboniferous Limestone, and locality Yorkshire.

Dr. H. G. Bronn rejected the name *Astrocrinites* on account of its resemblance to *Asterocrinites* of Münster, and proposed instead that of *Zygocrinus*. Römer, from the four-rayed structure of our *Astrocrinites*, allied it to the Cystoidea rather than to the Blastoidea. Prof. de Koninck and M. le Hon, however, referred *Zygocrinus* to the Blastoidea, and stated their reasons for so doing. Prof. Morris in 1854 altered Austin's *Astrocrinites* into *Astrocrinus*, and does not notice Bronn's name *Zygocrinus*. Prof. Pictet provisionally referred the latter genus structurally to *Codonaster*, noticing, however, its four instead of five pseudambulacra. The author then notices at some length the species he proposes to call *A. Benniei*, which appears to differ much from Austin's *A. tetragonus*. The body or calyx of *A. Benniei* is tetraradiate, having four convex lobes, three of which are alike, the fourth differing considerably from the others, the deep re-entering angles between the lobes are occupied by the pseudambulacra, the dorsal surface is densely covered with closely set tubercles, but shows no point of attachment, the ventral surface is flattened, having a large central aperture, from which radiate the four pseudambulacra; excentric as compared with the ambulacral system is a second and pyriform aperture of complex structure. The component parts are then minutely described, followed by careful descriptions of the pseudambulacra, apertures, and ornamentation, also a discussion as to the presence of a madreporiform tubercle. The second part of the paper treats upon the affinities of *A. Benniei*, Ether., with *A. tetragonus*, Austin. Part the third enters fully and critically into the systematic position of *Astrocrinites* amongst the Cystoidea and Blastoidea. In the concluding and fourth portion of the paper, the localities and geological horizons are given. Twenty-seven figures, occupying three plates, accompanied the paper.

3. "*On the* Genus *Merycochœrus* (Family Oreodontidæ), with de-

scriptions of two new species." By G. T. Bettany, Esq., B.A., B.Sc. Communicated by Prof. T. McKenny Hughes, F.G.S.

An account was given of remarkable vertebrate Tertiary skulls and other remains brought from Upper Oregon by Lord Walsingham in 1872, and presented by him to the Woodwardian Museum, Cambridge. The characters of the family of Ungulates (Oreodontidæ), to which they belong, and of the genera of the family, were referred to, and supplemented from examination of these remains. The genus *Merycochœrus*, previously known only from teeth and portions of jaws, was further defined and described from large skulls and portions of skulls. The remarkable size of the temporal fossæ, the form of the zygoma, and especially its great posterior transverse crest, are special points of interest. Finally two new species, *M. temporalis* and *M. Leidyi*, were defined and described.

II.—ANNUAL GENERAL MEETING.—February 18th, 1876.—John Evans, Esq., F.R.S., President, in the Chair.

The Secretary read the Reports of the Council and of the Library and Museum Committee for the year 1875. The position of the Society was described as very satisfactory, although, owing to various extraordinary expenses, the expenditure of the year was considerably in excess of its income. The Society was stated to be in a prosperous state, and the increase in the number of Fellows to be greater than in any previous year. The Report also referred to the bequest by the late Sir Charles Lyell of the die of a medal and of the sum of £2000, a bronze copy of the former and the interest of the latter to be given annually or from time to time by the Council as a mark of honorary distinction to some person or persons who shall be regarded as having aided the progress of Geological Science. It was also announced that Dr. Bigsby, F.R.S., F.G.S., has offered to found a bronze medal to be given in alternate years as an incentive to the study of Geology.

In presenting the Wollaston Gold Medal to Professor Huxley, F.R.S., F.G.S., the President addressed him as follows:—

Professor Huxley,—It is a source of great satisfaction to me that it should fall to my lot to place in your hands the Wollaston Medal, which has been awarded to you by the Council of this Society in recognition of your distinguished services to geological science.

Those services have been so great and are so universally acknowledged that it seems hardly necessary to dilate upon them. For a period of upwards of five-and-twenty years you have been engaged in biological researches, which have resulted in throwing a flood of light upon the structure, affinities, and development of organisms of every class, from those so simple as to occupy the border territory between the animal and vegetable kingdoms up to the highest forms of mammalian life.

Such researches cannot but have had a great and beneficial influence on geological thought. But your services to geology and to this Society are of a far higher and more direct character. Not only have you furnished to our 'Proceedings' numerous and valuable palæontological essays, but on three occasions, either as a President or as representing the President of this Society, you have delivered anniversary addresses which are models of the philosophical exposition of great geological principles, such as I sincerely wish it had been in my power this afternoon to imitate.

In addition to these services to the Society, you have, it may safely be affirmed, done more by your lectures than almost any other man to advance palæontological studies among those who are undergoing a course of scientific training, while to more popular audiences you have, by your vivid and lucid descriptions, rendered intelligible those marvellous natural processes by which such beds as our Limestones, Coal, and Chalk have gradually been built up.

As one of our former Secretaries, I know the deep interest you take in all geological pursuits, and I therefore venture to express a hope, in which all in this room will share, that the day may not long be distant when, with renewed health and strength, and a greater amount of leisure at your command, you may again be able to take a frequent part in the meetings of this Society, of whose appreciation of your labours this medal is the symbol.

Professor Huxley, in reply, said:—Mr. President,—I am so much more accustomed to the language of criticism than to that of panegyric, that I feel a certain difficulty in framing a reply appropriate to the address with which you have just honoured me.

To be enrolled among the eminent men who have been recipients of the Wollaston Medal is a distinction of which the most ambitious aspirant to scientific honours may be proud. The terms of personal kindness in which you have clothed the award of the Council, and the warmth of my reception by the meeting, lead me to hope that I may, in addition, regard the distinction which has been conferred upon me as a mark of the goodwill of the colleagues with whom in past years I have been so closely associated.

It is my hope and expectation, Mr. President, that the wish which you have so kindly expressed as to the resumption of my palæontological work, will be fulfilled.

The great biological question of the day is the problem of evolution; but geologists, as Kant says, are the archæologists of nature, and the sole direct and irrefragable evidence of the method whereby living things have become what they are, is to be sought among fossil remains. If I have in any degree merited the unexpected honour you have conferred upon me, it is because I have steadily kept this truth in view; and if I shall ever succeed in deserving the Wollaston Medal better than at present, it will be by further attempts to translate the archæological facts of nature into history.

The President then presented the balance of the proceeds of the Wollaston Donation Fund to Mr. J. Gwyn Jeffreys, for transmission to Professor Giuseppe Seguenza, of Messina, F.C.G.S., and addressed him in the following terms:—

Mr. Gwyn Jeffreys,—In placing in your hands the balance of the proceeds of the Wollaston Fund for transmission to our Foreign Correspondent, Professor Seguenza, of Messina, may I request you to convey to him at the same time our high sense of the value of his investigations upon the Tertiary beds of Italy and Sicily, on which he has already published such numerous and important memoirs.

Will you, in addition, express a hope that this mark of our appreciation may also prove of some assistance to him in the further prosecution of his researches.

Mr. Gwyn Jeffreys, in expressing the thanks of his friend Prof. Seguenza, said that this testimonial would not only be highly valued, but be especially acceptable, because the stipend of an Italian Professor was too small to enable him to prosecute his palæontological researches as fully as he could desire.

The President next handed the Murchison Medal to Professor Ramsay for transmission to Mr. A. R. C. Selwyn, F.R.S., F.G.S., and spoke as follows:—

Professor Ramsay,—I place in your hands the Murchison Medal and the portion of the Murchison Fund which have been awarded to Mr. Alfred R. C. Selwyn, F.R.S., in recognition of his services to Silurian geology; for no one can appreciate better than yourself the character and importance of his work, or can better convey to him the assurance of the high estimation in which it is held.

As one of the officers of the Geological Survey of this country, engaged in unravelling the intricate Lower Silurian Rocks of North Wales with their associated volcanic deposits; as afterwards in charge of the Geological Survey of Victoria, mapping its Silurian strata, its gold-bearing rocks and auriferous gravels of different ages, and tracing the relations of the latter to the Miocene beds of the colony and to the older rocks; as subsequently the successor of Sir William Logan in the direction of the Geological Survey in our North-American territories from the Atlantic to the Pacific Ocean, the labours of Mr. Selwyn have extended over an enormous field.

How successfully he has worked in it, the numerous and excellent maps and sections executed under his superintendence, and his various reports and papers fully testify.

There is something peculiarly appropriate in the Medal founded by Sir Roderick Murchison being given to one whose labours, like his own, have lain so much among Silurian and Palæozoic rocks, among gold-fields, and in the direction of geological surveys. While it marks our appreciation of Mr. Selwyn's services to Geology, it will, I trust, not be the less welcome to him as a proof that, though absent, he is not forgotten by his fellow-workers.

Professor Ramsay, in reply, spoke as follows:—

Mr. President,—On behalf of Mr. Selwyn, I return thanks for the honour that has been conferred on him. When Mr. Selwyn joined the Geological Survey of Great Britain many years ago, I may almost say that he received his first lessons in the art of Geological Surveying from me; but he very soon proved himself so proficient in the work, that a large part of the survey of the intricate Lower Silurian rocks of North Wales was executed by him in a masterly manner.

When the Geological Survey of the Colony of Victoria was established by the Colonial Government, Mr. Selwyn was selected to begin and conduct that work; and there also, with the help of Mr. Daintree, the Browns, and others, it was his lot again to be engaged on a great scale in unravelling the intricacies of Silurian geology. After that Survey was abolished, no one was considered so fit as he to succeed the late Sir Wm. Logan as Director of the Geological Survey of our North-American dominions; and there is therefore an appropriateness in the award of the Murchison Medal to one who has done so much excellent work *among Silurian rocks* in three regions of the world.

In presenting the balance of the Murchison Geological Fund to Professor Ramsay for transmission to Mr. James Croll, the President said:—

Professor Ramsay,—Will you convey to Mr. Croll the balance of the proceeds of the Murchison Fund, and at the same time express the hope of the Council of this Society that it may prove of service to him in the prosecution of those studies with which his name has been so long and so honourably associated.

His researches on Ocean Currents, on Glacial Phenomena, on the bearing of the latter on Geological time, and of both upon Climate, were generally known and appreciated, even before the appearance last year of his work on Climate and Time, in which the results of his studies are so carefully and ably expounded.

The author of that book would be the last to regard the subjects of which it treats as being all now definitely settled, and requiring no further investigation; and it is in the hope that his inquiries into the phenomena of glaciation, and into the physical causes conducing to extreme modifications of climate, may be still further prosecuted, as well as in recognition of the valuable past labours of Mr. Croll, that the fund which I place in your charge has been awarded to him.

Professor Ramsay, in reply, said:—

Mr. President,—In returning thanks on behalf of Mr. Croll, I have no need to enlarge on the merits of a man now so well known to geologists by his numerous memoirs, and now especially by his remarkable work, 'Climate and Time;' and though on a range of subjects so wide it is not to be expected that there should be no opponents to some of his views, there can yet be no doubt that the ability which he has displayed commands the universal respect of men of science and the adherence of not a few.

The President then handed to Professor Morris, F.G.S., the first Lyell Medal and the entire proceeds of the Fund, and addressed him in the following terms:—

Professor Morris,—This is, as you know, the first occasion on which the award of the Medal and the proceeds of the Fund so liberally bequeathed to the Society by our illustrious Fellow Sir Charles Lyell has been under the consideration of the Council. It has, I may venture to say, been unanimously felt, that it was impossible to find a more worthy recipient than yourself; and that, in awarding both the Medal and the available proceeds of the Fund to one whose name was so intimately connected with the progress of Geological science, we were best carrying out the intentions of the founder, and attaching an importance to the Medal which would show that, though founded later, it takes equal rank with the other medals at the disposal of the Council.

You have been a Fellow of this Society for upwards of thirty years, but the published results of your geological investigations extend over a period of more than forty. Your 'Catalogue of British Fossils' has long taken rank as a standard work, while your communications to this Society, both on Geological and Palæontological subjects, have been of high value and importance. Your lectures have done much to spread a taste for Geology, and to enlarge the number of its students; and those who have heard you take part in our discussions must have been alike astonished at the minuteness of your knowledge of every branch of Geology and Palæontology, and at the powers of memory by which you were enabled to apply it.

I have much pleasure in handing the Lyell Medal to one who, like its founder, has rendered such long and meritorious services to our science, and am glad that under the wise and liberal provisions of the bequest, this token of our appreciation is accompanied by a sum which may prove of assistance in enabling you to carry still further your valuable observations and researches.

Professor Morris replied as follows:—Mr. President,—In receiving at your hands the first award of the medal founded by Sir Charles Lyell, I cannot but deeply feel the distinguished honour which the Council of the Geological Society have this day conferred upon me. It is unnecessary to advert at this meeting to the works of an author whose labours in the field he earnestly cultivated have so greatly enlarged the bounds of geological knowledge and influenced the tone of geological thought. I may say, Sir, that it was chiefly by reading the first edition of Sir Charles Lyell's "Principles of Geology," and his review in 1827 of Poulett Scrope, that I was led to perceive their philosophical bearings, and was stimulated to continue geological research, for although the "Theory of the Earth" had been illustrated and supported by the eloquence of a Playfair, it was the indefatigable activity of Lyell, and his constant accumulation and assimilation of new facts that led to the general acceptance of the principles advocated by Hutton. Hence, whilst I cannot but feel strongly impressed by the kind appreciation of the Council in this award as a recognition of my sincere but imperfect attempts to assist the progress of geological science, the gratification I experience at this unexpected honour is greatly enhanced by the consequent association of my name with that of Lyell.

The President then proceeded to read his Anniversary Address, in which, after congratulating the Fellows on the continued prosperity of the Society, he took occasion to indicate what seemed to him the principal directions which the geological research of the future would have to take. Referring to the facts as to the present constitution of the sun revealed by spectrum-analysis, and their bearing upon our conception of the early condition of the earth, and hence of its present state as regards internal fluidity and thickness of crust, he indicated as a probable inference from these considerations that there must have been changes in the position of the earth's axis. He referred also to the discoveries made by the naturalists of the "Challenger" Expedition, with regard to the distribution of *Globigerina*-ooze and greensand and red clay deposits at various depths, and indicated the important bearing of these observations, and the inferences founded upon them as to many questions relating to the origin of rocks. With regard to the climate of the Arctic regions in past times, as recorded in the fossils found there, he expressed the opinion that none of the geological hypotheses hitherto proposed sufficed to account for these phenomena. After noticing some other points, the President criticized the scheme suggested by "glaciers are able to scoop out vast depressed areas of enormous depth in their beds." For my own part, I can honestly assure those gentlemen, that I never for one moment dreamt of making any such wild attempt; nor did I ever lose sight of the fact, that in this indictment of the glaciers for lake-making, the task of substantiating the charge against them rests with those who have advanced it. The verdict for which I contended, and with which I shall be perfectly satisfied, is one of "not proven."

The manner in which Prof. Ramsay and Mr. Geikie endeavour to obtain a conviction against the glaciers is as follows. They urge that there are certain rock-bound basins of which the formation can be ascribed neither to marine nor to river action, and with regard to which there is a total want of evidence by which their origin can be referred either to special subsidence, to synclinal folding, or to faulting of the rocks among which they lie. This premised, they proceed to triumphantly announce their conclusion:—"But one agent is left, and that is *ice!*"

Now, it is clear that the whole force of this reasoning depends on the completeness with which the authors of it have cited and disposed of the competence, not only of every possible agency, *but also of every possible combination of agencies*, by which the lakes in question could have been formed, except that of ice-excavation. It is just at this point that I venture to join issue with them.

Just as in the well-known fable, the article was most undoubtedly stolen, though one of the culprits was able to declare that he "did not take it," and the other that he "had not got it," so there are lake-basins with regard to which it may be very safely asserted that meteoric action could not have excavated them, nor could subterranean forces have moulded them; but concerning which it is, nevertheless, also true that the two agents, *acting in conjunction*, are able to give a perfectly good account.

Prof. Ramsay holds that my line of argument may be "easily disposed of," and Mr. Geikie that it has been "answered already." They will forgive me for reminding them that the only reply that has ever been vouchsafed to it altogether and most signally failed to convince the candid and truth-loving mind of the late Sir Charles Lyell, as every reader of "The Antiquity of Man," and the "Student's Elements of Geology," must be well aware. Dr. Hector, too, in replying to Captain Hutton (who reproduced this "answer" of Prof. Ramsay), follows precisely the same line of argument as Lyell—an argument of which the validity and force are admitted by almost every Alpine geologist. What a happy thought then must that have been to the author of "The Great Ice Age," when it occurred to him to carefully avoid all mention of Lyell's objections to the theory;—such a discreet, and withal *convenient*, way of dealing with the question!

Far be it from me to rely in this matter on any authority, however eminent, or to cite the opinions of a majority, however overwhelming. But when we are gravely assured that this notion of the erosion of lake-basins by ice "bids fair to become one of the most generally accepted theories in geology," is it possible to avoid a smile at the very sanguine temperaments with which the promoters of this theory would appear to be so happily endowed?

I have, however, to thank Prof. Green for so fairly raising what is the real point at issue in this controversy—that of the relation between the effects of subterranean and subaerial forces. He tells us that he and his friends are prepared to admit that *before* denuding agents can carve out hill and valley, the subterranean forces must have brought the rock-masses within their reach; he is moreover convinced that the *original* lines of drainage must have been determined by the action of the same forces; and, still further, that, though the details of the contours of mountains are due to meteoric agencies, their superior elevation is the result of the concentration of subterranean energy beneath them.

So far well! But will my friend permit me to invite him to accompany me just one step farther in the same direction. Is it not certain that *not only before the commencement* of the slow process of sculpturing by meteoric agencies (in which we are both such firm believers), but actually *while those forces are in operation*, subterranean actions, attended by more or less local surface movements, were going on *side by side* with, and modifying the effects of. the subaerial forces? Does he shrink from this admission? If so, why? Has he any grounds for the belief that all the subterranean action took place at one period, and all the subaerial at another? Such an admission as I ask him to make would never have alarmed either Lyell or Scrope, who fought a good fight for the Huttonian doctrines before almost any of us the younger champions of the theory were born! Is there anything in it inconsistent with the teachings of Hutton and Playfair themselves?

Have not our perceptions become just a little numbed through our dwelling too long in the region of glaciers? Geology has had its day of universal deluges; it is now passing through its "*great ice* age." We are persuaded, however, that as it has survived the former, it will emerge safely from the latter; and even now we begin to see the signs of the setting in of more temperate mental conditions. I cannot help venturing to hope (for may not I too be *sanguine*, for once?) that at no very distant date I may have the pleasure of wandering with my four opponents of to-day among Alpine or Scottish lakes, all joining in a hearty laugh at the strange theory that was once maintained concerning their origin.

John W. Judd.

GLACIAL EROSION.

Sir.—In Mr. Judd's very interesting paper on Lake Balaton, there is, besides a vindication of the claims of subterranean forces to be the true originators of lakes lying in rock-basins, an attempt to show that glacial erosion can never be regarded as a *vera causa* in any case in the formation of lakes.

I am afraid that the eminent geologists who write on behalf of glacial erosion, as one of the causes producing lakes, in the current number of the GEOL. MAG., will not succeed in converting Mr. Judd to their views, as they have omitted to notice one point, if not *the* point, which prevents him from giving any recognition to that agency. On p. 15 he states that only by those who ignore altogether the action of subterranean forces "the necessity is felt of assuming that *rivers of ice* possess a power, which is on all hands admitted does not belong to *rivers of water* (the italics are Mr. Judd's)—that of excavating great basin-shaped depressions in their course." But, surely, rivers of water do often scoop out basin-shaped depressions. As a good example may be mentioned the Atbara, so well described by Sir Samuel Baker in "The Nile Tributaries of Abyssinia," which, except in the rainy season, is simply a dry bed, with here and there, in its course, pools of considerable size abounding in fish, crocodiles, and hippopotami. So that we have only to suppose a river of ice endowed with similar excavating power, and its capability of producing lakes in its course, and the probability that it will do so, are evident.

T. V. HOLMES,
H.M. Geol. Survey Eng. and Wales.

WIGTON, CUMBERLAND,
March 10th, 1876.

NOTE ON AN ANNELID BED IN THE GAULT OF KENT.

SIR,—I have been much interested in reading the note on the above subject by Prof. Rupert Jones in the March Number of the GEOLOGICAL MAGAZINE. I take this opportunity of stating that I am well acquainted with the narrow hard band he mentions, as occurring in the Lower Gault of Folkestone, which is probably similar, if not identical, with that found at Westwell Leacon, near Charing.

Although I did not actually note the occurrence of this hard band as bored by Annelids, still, if my paper on the Gault of Folkestone (Quart. Journ. Geol. Soc., 1874, vol. xxx. p. 347) be referred to, it will there be seen that in describing Bed III. I have mentioned the occurrence of tabular masses of ironstone, as being met with in this bed, being of the same light fawn colour as the clay. It might almost be said to be red externally, especially when slightly weathered. Upon breaking open a fragment of this hard seam, it was seen to be completely riddled with Annelid borings, which were filled up with blue clay. Finding that these masses were far heavier than the clay from any of the beds, I asked Mr. Hudleston to give me an analysis of it—the result being, it was found to contain as much as 30·40 of metallic iron.

Large tabular slabs of this seam may be found lying on the beach in Eastwear Bay, being washed out of Bed III. I have a fragment in my cabinet which is one inch in thickness, but I do not think the seam is ever found thicker than 1½ inches at Folkestone. Yet, as Prof. Rupert Jones has met with this seam near Charing, about two inches in thickness, it is an additional evidence of the Gault thickening out gradually towards the north-west, as at Burham the Gault has a total thickness of about 200 feet.

With regard to the Foraminifera, I am aware that they are plentiful *in the Gault*, particularly in the lower beds; but as I had never studied them in detail, I omitted to include them in my list of fossils, as I did all that either John Griffiths or myself did not actually find in situ; as my object was merely to notice what the fauna was in each bed Many forms I omitted from the list on account of being unacquainted with their horizon.

Had my intention been otherwise, I should have recorded the list of Foraminifera that appeared in Morris's Catalogue; Mr. Topley's more ample list not being published at the time my paper was read.

Mr. De Rance found *Rotalina umbilicata* in his Bed V., which is the same as Bed VII. in my table. F. G. HILTON PRICE.

OBITUARY.

◆

COLONEL GEORGE GREENWOOD.

BORN JUNE, 1799; DIED 3RD NOVEMBER, 1875.

ALBEIT it is long after date, we cannot omit to pay our tribute of respect to an English gentleman, who, had he fallen amongst Geologists in early life, instead of amongst "thoroughbreds," would doubtless have occupied a leading place among men of science. Col. George Greenwood, who was the son of Mr. Greenwood, of Brookwood Park, Alresford, Hants, was educated at Eton, and entered the Army as a cornet and sub-lieutenant in the 2nd Life Guards in 1817, just after the memorable period of Waterloo. He rose rapidly in his profession, although he was never called upon active service. Lieut.-Col. in 1831, and Colonel in 1838. He was highly esteemed as an officer, and was a celebrated athlete, and the finest horseman of his day. Among the useful reforms which he introduced into the Household Cavalry, it is still gratefully remembered that he reduced the weight of the helmet from 8lbs. to 3lbs.! He was highly esteemed for his horsemanship by William IV., and received marked distinction from the young Queen Victoria; but in 1840, owing to an affection of the heart, his physician (Dr. Chambers) advised his retirement from the Army. Living thenceforward the life of a country gentleman in Hampshire, planting and transplanting trees, he devoted much time to reading. In 1844 he published the first edition of "The Tree Lifter," and in 1853 a second and larger edition, in which some of his geological observations were incorporated. In 1857 Col. Greenwood published the first edition of "Rain and Rivers," in which he showed great powers of observation and shrewd reasoning on the influence of meteoric agents in shaping the form of the ground, especially in reference to the atmospheric origin of all river valleys. His trenchant and original style of thought attracted the attention of Professors Ramsay and Jukes, and his book having been highly commended, he issued a second edition in 1866. He was a voluminous writer, and his letters were always appearing in the columns of the *Athenæum*, in *Nature*, and in this MAGAZINE. He also wrote occasional articles on Valleys and their mode of formation.

Just as in the hunting field he rode hard, so in his letters and book he strove to outride all opposition, and having found by observation a *vera causa for the formation of* valleys, he believed it to be THE

CAUSE, AND THE *only cause*. Glaciers he disowned, contending that rain and rivers could do all the work very well without them.

Although a determined opponent in a controversy, he was a highly polished gentleman in his manners, and courteous to all with whom he came in contact. An avenue of purple beeches down the Deane, near Brookwood, will serve *in memoriam* to recall the author of the "Tree Lifter" and of "Rain and Rivers."—His nephew, Mr. Charles W. Greenwood, is preparing to re-issue his books, accompanied by his extensive scientific correspondence.

ADOLPHE THEODORE BRONGNIART,

MEMB. ACAD. FR., FOR. F.R.S., ETC., ETC.

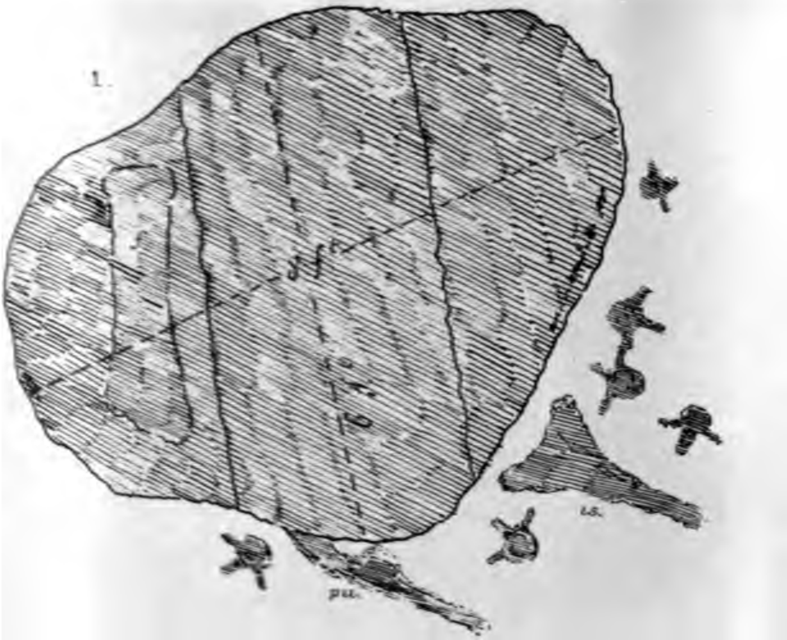
BORN 14th JANUARY, 1801; DIED 18TH FEBRUARY, 1876.

THIS illustrious French botanist has for half a century justly occupied a prominent place as a man of science. He was the son of Alexandre Brongniart, the famous naturalist, who died in 1847. At the age of nineteen he wrote his first and only zoological paper on a new genus of Crustacea. He afterwards devoted himself wholly to Botany, especially to the study of fossil plants. In 1828 he commenced his great work. "Histoire des Végétaux Fossiles, ou Recherches Botaniques et Géologiques" (4to. pp. 488, illustrated by 166 plates). The work was arrested by M. Brongniart's ill-health when it had reached to 12 parts, and was not resumed for nine years. Only three additional parts were then issued, and the work remains incomplete, to the great regret of all students of Fossil Botany. M. Brongniart wrote the article on *Fossil Plants* in the "Dictionnaire d'Histoire Naturelle" (1849). He also contributed numerous separate papers on Recent and Fossil Botany to the *Annales*, etc.

MISCELLANEOUS.

AUSTRALIAN GEOLOGY.—We have received the first sketch of a Geological Map of Australia, including Tasmania, prepared by Mr. R. Brough Smyth, Chief Inspector of Mines. Although on a small scale (about 110 miles to the inch), it is neatly executed, and affords an excellent summary of the present state of Australian geology. Considerable areas are still uncoloured; but, even as now known, all the three great geological periods are represented. The crystalline and igneous rocks, including granite, trap, newer and older volcanic, are largely developed. These igneous rocks of different ages form a prominent feature of the eastern and western districts, where also occur the Silurian, the Carboniferous of Palæozoic and the Carbonaceous of Mesozoic age; but the far larger portion of the interior, now explored, especially the western half of the continent, is composed of Cretaceous and Tertiary strata, either of Oligocene, Miocene, or Pliocene age. The Map therefore forms a very good and useful index to the relations and distribution of the different geological formations as at present known on the Australian continent.—*J.M.*

1.



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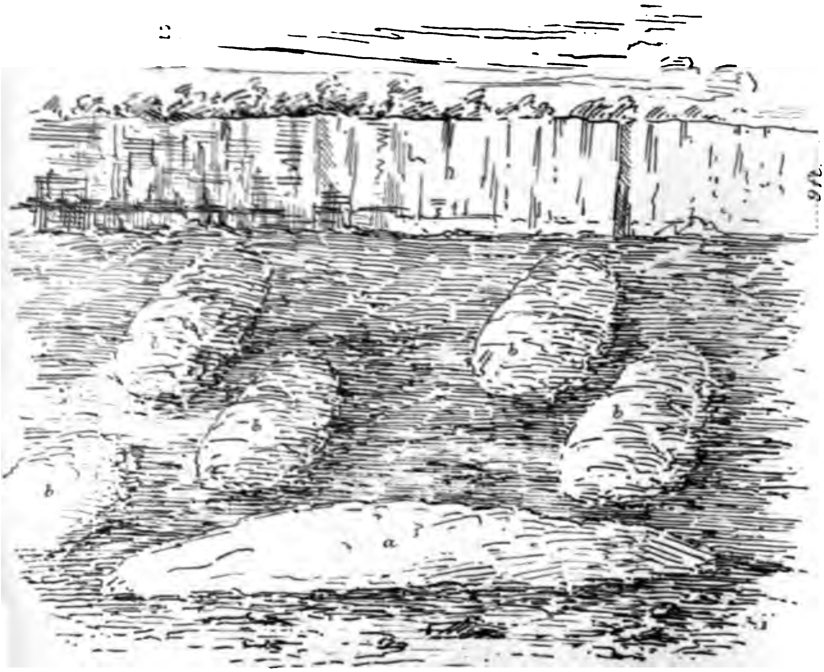
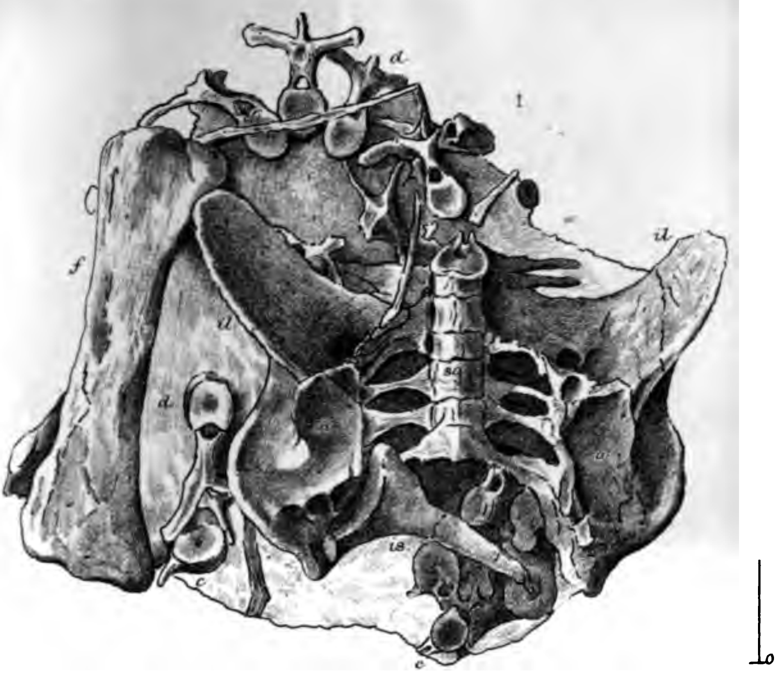
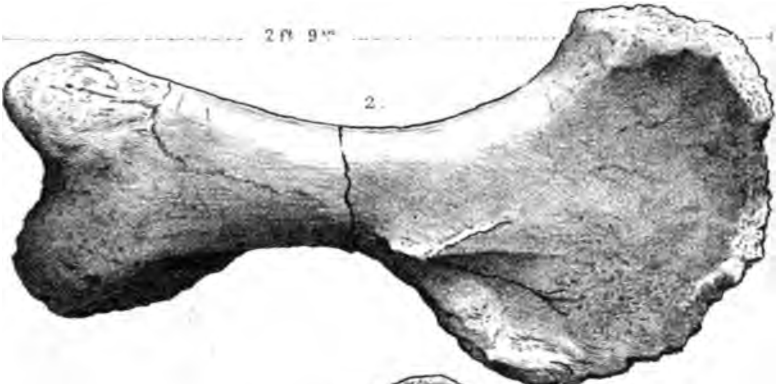


Septaria in Kimmeridge Clay, Swindon.





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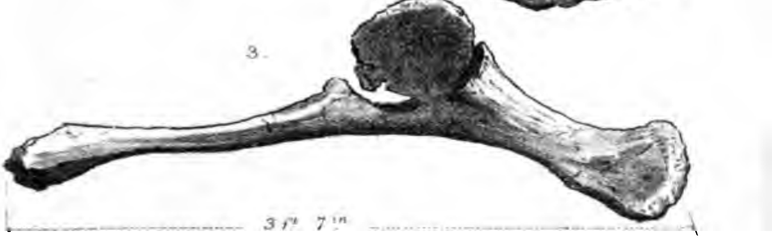

3.

Omosaurus armatus, – Owen. –

W. West sc.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE II. VOL. III.

No. V.—MAY, 1876.

ORIGINAL ARTICLES.

I.—On the Exhumation and Development of a large Reptile (*Omosaurus armatus*, Owen), from the Kimmeridge Clay, Swindon, Wilts.

By William Davies, of the British Museum.

(PLATES VII. and VIII.)

COMPARATIVELY few of the many persons who visit our larger Museums, and stop to examine the fossils exhibited in the cases, have any idea of the time, labour, care, and mechanical skill which many of them require ere they are ready for the palæontologist to interpret and describe, the artist to delineate, or made sufficiently intelligible for public exhibition. The first operation, and one requiring considerable care, is the exhumation of the fossil remains from the stratum of gravel or clay, or from the siliceous or calcareous rocks of various degrees of hardness, in which they may have been imbedded and preserved. Then the hardening of the bones—for these remarks apply more especially to the remains of the larger Vertebrata—which are generally found much broken, and, unless thoroughly mineralized, in a more or less friable and brittle condition. Next there is the fitting and cementing together of the pieces, which are frequently numerous, and of such as have been imbedded in a rocky matrix, the careful development by hammer and chisel from their incasement of stone: all of which operations necessarily involve a large amount of skilled labour.

The late Prof. Phillips wrote a graphic description of the discovery, mode of exhumation and restoration of the remains of the huge *Cetiosaurus* discovered in 1869, in a quarry in the Great Oolite at Elmslow Bridge,[1] and now preserved in the University Museum at Oxford.

The discovery in 1874 at Swindon, Wilts, in the upper beds of the Kimmeridge Clay, of another huge Dragon, somewhat smaller in dimensions than the Elmslow giant, yet of scientific value and importance equally as great to the Palæontologist, being the subject of an important monograph by Prof. Owen, F.R.S.,[2] and also as it has been recently placed for exhibition in the Geological Gallery of the British Museum, may possibly render a short record of its occurrence and the method adopted for exhuming and developing it acceptable to the readers of the Geological Magazine.

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[1] See *Athenæum*, April 2nd, 1870.

[2] In the Palæontographical Society's volume for 1875. Monograph of a Fossil Dinosaur (*Omosaurus armatus*, Owen), from the Kimmeridge Clay, pp. 45-93, plates xi.-xxii.

The Directors of the Swindon Brick and Tile Company having in May, 1874, informed Prof. Owen that many large bones had been discovered and laid bare in their Brick-pit by the workmen, I was instructed to proceed thither to examine and report if they were desirable objects for the National Collection. On arriving at the works, which are situated at the foot of Old Swindon Hill and adjoining the Wilts and Berks Canal, I found exposed on the floor of a newly-worked portion of the pit and at a depth of about nine feet from the surface of the clay six large nodules of septaria, one being more remarkable than the others, not only on account of its superior size, but also that it showed here and there small portions of bone protruding from its upper surface (see Plate VII.). In one portion of this mass, although deeply imbedded in the stone, the outline of a limb-bone could be traced, fully four feet in length, which I concluded to be a femur, and in addition, either projecting from its margin or in close proximity to it, and lying undisturbed in the clay, were two large pelvic bones (ischium and pubis), and six caudal vertebræ having centra six inches in diameter; processes of some of these were imbedded in the septarium, as was also one end of the pubic bone (see Plate VIII. Fig. 3). These bones ranged along a third of the marginal circumference of the nodule, which was of a flattened irregular elliptical form, measuring eight feet in its longest, and six feet in its shortest diameter: the margin was thin in places, but the general thickness of the nodule ranged from 12 to about 20 inches. About four feet from this group of bones and upon the same level was another group, which consisted of an entire humerus (Plate VIII. Fig. 2), ulna and radius. The distal ends of the humerus and ulna were enclosed and cemented together in a small block of septarium, which had to be broken before they could be removed. Subsequently, on further digging, carpal and metacarpal bones were found in proximity to this group, all being parts of the same fore-limb. These remains, and the vertebræ more especially, I supposed to have belonged to a reptile allied to *Cetiosaurus*, but new to science, and reported accordingly, making preparations at the same time for their removal.

The exhumation of the bones which were lying in the clay was readily effected by the method already described in the pages of this Magazine (see Geol. Mag., 1865, Vol. II. p. 93). But how to remove from the pit this large block of stone without injuring and destroying the enclosed bones was a problem, for to raise it entire with such appliances as we had was impossible. Yet its safe removal was imperative in the interests of science, as I believed it contained a large portion of the posterior part of the skeleton of the animal. Before deciding upon any special plan of operation, and to ascertain if the nodule was really compact and firm, a trench about a foot deep and several feet in length was dug along its margin; a workman was then instructed to insert his pick beneath and try slightly to raise the mass, which was then found to be cracked in many places, although no cracks were before visible. Matters now looked promising, for it seemed possible to remove this concretionary mass in large blocks which could be afterwards reunited. When, however, after some further trenching around and digging beneath, we attempted to lift the first block—a nearly square mass about eighteen inches across—from the clay on which it was first formed, and where it had reposed for ages, it fell from our hands in many pieces by its own weight, and its enclosed bone was found to be wet, rotten and crumbling. Thus all the sanguine expectations of success which the fissures had raised were cast down, for should the whole nodule fall into small pieces as this portion had, the prospect of preserving the imbedded bone seemed hopeless. However, after careful examination it was found that no other method than taking it up in blocks was practicable, and preparations were made for removing it accordingly. Each block as it was taken up was numbered, and each piece into which it fell was marked with the same number, the smaller pieces being wrapped in paper, also numbered, and then ranged in separate heaps in an unused kiln. Every block when first lifted from the clay broke into many pieces, and every subsequent removal, in their transit from the pit to their final deposition in the National Collection, added greatly to the number. The contraction caused by the rapid drying of the mass in the sun, whilst lying in the pit, was also a source of disintegration; for the calcareous particles of which the septarium was composed, although hard, had but little cohesion, and broke readily into small cuboidal fragments with a short and clean fracture; whilst the quantity of bone it contained, which was all in a more or less crumbling condition, and the veins of crystalline calcite that traversed it in several directions were also sources of weakness.

The exhumation being completed, the whole mass, packed in many cases (stone, clay, plaster and bones, weighing nearly three tons), was forwarded to the British Museum. When unpacked, the pieces—which now amounted to many hundreds—were ranged in groups, and had more the appearance of heaps of worthless rock debris, rather than of fragments to be united, and from which was to be extracted the symmetrical bones of a huge reptile. The work of reconstruction was at once commenced; the bones imbedded in the clay were divested of their plaster casing, gelatinized and mended, for they were much decayed and broken. Piece by piece the septarium was fitted and cemented together, until the pieces were formed into great blocks, but not too big for convenient handling; these again were fitted and placed together so as to restore the nodule as nearly as possible to its original shape; but its surface, owing to its numerous joints, bore some resemblance to a very irregular piece of tessellated pavement, or to a curious Chinese puzzle. These large blocks were then united and firmly cemented, so as to form three masses of nearly equal proportions. This was readily effected, for fortunately I had discovered, in the course of removing it, that the nodule had two parallel cracks running across its short diameter which divided it into three nearly equal parts;[1] these again, when the work of development was far advanced, were fixed and joined together in a frame, and now present the appearance of an entire slab.

And now commenced the principal work, that of cutting away the upper surface of the block, and tracing the imbedded bones, for as yet, with the exception of the femur already mentioned, and some centra of vertebræ, it was not certainly known what parts of the skeleton the stone enclosed. This was a work of much labour, patience and skill, for the matrix was hard and adhered firmly to the bone, which, being much softer, rendered it almost impossible to remove the former, without also taking away the surface of the latter. However, slowly but satisfactorily the work progressed, and bone after bone was brought to light, until a grand group, comprising the iliac bones of either side with the sacrum entire and retaining their normal form and position, an ischium, femur, dorsal, and caudal vertebræ, were projected in bold relief from a background of grey stone: forming a magnificent fossil group unique of its kind (Plate VIII. Fig. 1). This work was skilfully executed by Mr. Barlow, the mason attached to the Geological Department, and occupied him several months. But happily the labour has added much to palæontological knowledge, as witnessed by Prof. Owen's Monograph already referred to, and the results have been a source of gratification to those who took part in its reconstruction.

In addition to the bones above mentioned, a large dermal spine, several centra and processes of many vertebræ, chevron-bones, portions of ribs, and numerous fragments of other bones, had been found and taken up by the workmen, before the larger bones were exposed, and these fragments unquestionably prove that many, if not most of the vertebræ were lying around the central mass, and also lead to the inference that, had some competent person been present at the moment of its first discovery, a much larger portion of the skeleton would have been secured; for undoubtedly many a fine fossil is lost to science through the general ignorance and carelessness of the workmen, and the strong propensity on the part of the public to carry off *portions* of any *curiosity* for the mantel-shelf!

In the same workings have also been found remains of *Pliosaurus*, *Plesiosaurus* and vertebræ of a new species of *Bothriospondylus* (*B. suffossus*, Owen), the latter of which are described in the Monograph referred to; and also the defensive spines of a fish, *Asteracanthus*, Shells of Ammonites, numerous small Oysters, and other Mollusca abound in the clay, but they are all compressed and too friable for removal.

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[1] The surfaces of these cracks were completely covered with a felting of the rootlets of plants, which had penetrated through some eight or nine feet of compact clay to this nodule, and had long fed upon and derived nourishment from the decayed bones of the old monster within it. At least I assumed this much from the fact, that I had all the other nodules broken up to see if they contained any bones, and although they were much cracked, in none were there any traces of rootlets; nor did I find in one of them any organic remain which could have served as a nucleus of concretion. The form of each was elliptical, more or less elongated, and they were large, measuring several feet in their long diameter, and were traversed by veins of crystalline calcite, having also large cavities and fissures lined with crystals of the same mineral. The nucleus of all these nodules of septaria was probably organic, but may have consisted of more perishable organisms than bones, and so have been slowly dissolved *and removed, leaving* the cavities lined with spar to mark their former presence.

EXPLANATION OF PLATES.

PLATE VII.

Fig. 1. Rough diagram of principal mass of septarium in which the greater part of the remains of *Omosaurus armatus*, Owen, were enclosed.
f. the right femur in situ. *pu.* the right pubic bone projecting from the nodule into the surrounding clay-bed. *is.* the left ischium. Six caudal vertebræ (*c*) are also seen lying near the septarium in the clay.

„ 2. General view of the pit at Swindon, showing the relative position of the large septarium (*a*) and the five adjacent septaria *b*, *b*, *b* (from a rough sketch by the author).

PLATE VIII.

Fig. 1. *Omosaurus armatus*, Owen, as it appeared after development from the septarium.
sa. the sacrum. *il.* the iliac bones. *a.* the acetabulum into which the femur (*f*) was articulated. *is.* the ischium, nearly in situ. *d.* the dorsal vertebræ. *c.* the caudal vertebræ.

„ 2. The left humerus.

„ 3. The right pubic bone.

II.—Some Notes on Glaciers.

By the Rev. T. G. Bonney, M.A., F.G.S.

As missiles are falling thick like hail upon Mr. Judd since his challenge to the Glacialists, I take the opportunity of putting together a few notes, made during an Alpine journey last summer, which would have been published sooner, had more time been at my disposal. The lower parts of the Gorner, Arolla, Des Bossons, Des Bois, and Argentière Glaciers were carefully studied, but others received passing attention.

1. *Ground Moraine.* — The Glaciers of the Swiss and Savoy Alps have been retreating for several years; hence if anything like ground moraine existed, this would be a very favourable time for observing it. In no case have I been able to find signs of any deposit resembling Till or Boulder-clay; the detrital matter which is scattered, generally sparsely, over the slope left bare by the retreating glacier, has fallen from its surface, like ordinary terminal moraine. Further, by availing myself of crevasses, etc., I have made my way occasionally for some little distance beneath the ice. Nothing has been seen but bare rock, with now and then a film of mud or a passing stone. In short, the result of an experience of some years has convinced me, that if anything like the Till or Ground Moraine of recent glacialists exists in the Alps, it is a very local and exceptional phenomenon. It had sometimes occurred to me, as I believe it has to others, that much till-like matter might be produced from a residuum of stones and mud which had been once involved in the ice of the glacier. My more careful observations during the present year have shown me that these cases of included materials are more exceptional and less abundant than I had anticipated.

2. *The Erosive Power of Glaciers.*—As I have already several

times stated, it seems to me very difficult to reconcile the great erosive power attributed to glaciers with a great till-productive power, when overriding their terminal moraines and the rubbish in the lower valley. Some facts which I noticed last summer appeared to have an important bearing on this question. At the present time, the end of the Glacier des Bois just reaches the level bed of the Arve valley, and reclines on ice-worn rocks, with its extremity fitted into a sort of glen or ravine, not more than about thirty yards across. Below it there is a stony plain covered with the usual mixture of rounded and angular blocks—mica-schist, gneiss, protogine, etc. Among these, a short distance from the end of the glacier and rather near the left bank of the valley, is a huge block of protogine about 12×8 yards area and 4 high. The top of this, and to some extent the sides also, are striated by ice moving in the direction of the present glacier. The Glacier of Argentière is in a nearly similar position; about the last fifty yards rests on the stony bed of the Arve valley, the remainder lies on rocky slopes. In front of it there is an extensive area, now covered with boulders, which, within the last few years, has been abandoned by the ice, and is inclosed by a comparatively fresh terminal moraine. Many of the smaller blocks on this area, now almost concealed by rubbish scattered from the retreating glacier, are smoothed and striated as if by passing ice, but the general uniformity, however, of their upper surface is unfavourable to the idea of the glacier having any great power of "churning up" the deposit beneath. Here and there are large prominent protogine blocks, several of which distinctly show by the striations on their sides and surface, that the glacier has flowed over them. Three lie near together; their tops are polished and striated, and littered over with moraine; they do not form part of a lateral or ordinary terminal moraine, but are in an open plain. Striations, *stoss* and *lee seite*—everything is just as it should be had the glacier flowed over them, and each has a "tail" of moraine. The largest was about 12×7×5 yards.

To return to the glacier itself. Where the ice rests on the level stony plain, the subjacent materials, so far as I could make out, are little if at all disturbed. This fully agrees with everything that I have ever observed, viz. that when the glacier is passing over level or slightly inclined materials, it does not much disturb them, but thrusts up in front, when advancing, at most a mere scarf skin of turf or debris. I questioned my guides, Franz Bürgener and Jean Martin, both men of experience and more than ordinary intelligence. They gave it as their belief, that when a glacier descends a slope of moderate inclination, there is only bare rock beneath; when it passes over a tolerably level surface, it overrides the debris in front, without much disturbing it.

The slope of rock, a considerable portion of which has now been exposed by the shrinking of the glacier, lies at an angle of about 15° or 20°. On ascending that on the left bank for some little distance, I found it possible to pass between the ice and the rock, and availed myself of the opportunity, making sketches of the largest grotto. I copy the following from my note-book as the result of my observations: (*a*). The ice, when in contact with the rock, was remarkably clean (as was the rock), and but few stones were frozen into it. The glacier adapted itself very remarkably to the inequalities of the rock (a gneiss, not protogine), actually fitting itself into hollows some 2 feet deep by 3 or 4 wide. (*b*). The ice, though thus filling up the larger inequalities, does not quite fit into the smaller. The unworn space at the base of a *lee seite* cliff depends on several things, but speaking generally it rarely exceeds the height of that cliff, and is narrower on steep than on gentle slopes. (*c*). The ice appears to enter these cavities, not by fracture and regelation, but by change of form, as in the case of a plastic body, for it is remarkably clear and solid-looking. (*d*). Looking into the exquisitely blue mass of the glacier, I saw here and there a little pocket of mud imbedded, and a few stones; but I think 27 cubic inches of rock to a cubic yard of ice would be much above the average proportion. (*e*). There were no signs whatever of the glacier being able to break off or root up blocks of the subjacent schistose rock; it seemed to simply wear away prominences.

It may be well to warn persons unaccustomed to glaciers that, in examining their flanks and ends, there is often danger from falling ice and stones. In doing the above work, I always acted under the advice of an experienced guide, and know the habits of glaciers pretty well myself; yet, in the afternoon of the day when these observations were made on this Argentière glacier, many tons of ice fell either on or very near to a place where we had been working.

To conclude. The above observations tend to show that ice is a far more plastic substance (be the cause of the plasticity what it may) than some physicists would allow, and this has been confirmed by the remarkable experiments of Herr Pfaff, an account of which (*Nature*, vol. xii. p. 316) was almost the first thing to meet my eye on my return to England. They further indicate that this very plasticity, which in some respects is favourable to, in others militates against, its erosive power; as it occasionally flows, after the manner of water, over and round an obstacle, instead of sweeping it away, and appears to pass over debris, as a river does over a gravelly bed. I am thus confirmed in my view that "Ground Moraines," in the ordinary sense of the word, are very exceptional, and that the explanation commonly given of Till (*e.g.*, Great Ice Age, p. 87) is incorrect. Further, I am confirmed in regarding a glacier as an agent of abrasion rather than of erosion, and though I admit that on the whole it seems sometimes the simpler plan to attribute to the action of glaciers certain tarns and even small lakes, yet when I come to study them in detail I am confronted with so many indications of the inability of glaciers to excavate, except under peculiarly favourable circumstances, that I feel convinced great caution must be exercised in referring to their action a rock basin of even moderate dimensions.

III.—CONTRIBUTIONS TO THE STUDY OF VOLCANOS.—SECOND SERIES.

By JOHN W. JUDD, F.G.S.

ON THE VOLCANIC OUTBURSTS WHICH PRECEDED THE FORMATION OF THE ALPINE SYSTEM.

OF all the physical features of our continent, that which most powerfully arrests the attention is the noble chain of the Alps, with its wide-spreading system of subordinate mountain-ranges; and among the series of grand events, which by the researches of the geologist are demonstrated to have taken place on this our own portion of the globe, there are none more striking and conspicuous than those manifestations of subterranean forces to which the vast mountain-masses in question owe their origin.

As we now know, the great centres of crystalline rock, which for the most part constitute the axial portions of the Alpine ranges, do not represent any *primitive* formation—portions of the surface of a melted globe, as it originally cooled, or deposits of an ocean still in ebullition,—as old writers on geology used to imagine; but, on the contrary, they are found to consist in great part of sediments formed during different geological periods, which, long subsequently to their deposition, were, by the action of tangential mechanical strains, folded and crumpled, and by the agency of chemical forces developed in their midst, were transformed into their present highly crystalline condition. The sedimentary rocks out of which these crystalline masses have been formed were, as we now recognize, deposited during different Palæozoic, Mesozoic, and Tertiary epochs; and the forces by which they have been metamorphosed and have acquired their present elevated, contorted, and even inverted positions, have for the most part operated during what the geologist regards as comparatively recent periods; indeed, the most powerful of all the series of movements to which the Alpine chains owe their origin must have taken place during the latter half of the Tertiary epoch. The highly crystalline rocks of the central portions of the Alpine chain are not the *oldest* formed portions of their masses, but the *youngest* —and are the result of the extreme metamorphism of the most violently disturbed portions of sedimentary deposits, some of which are of as recent date as the Tertiary, and of the intrusion into their midst of aqueo-igneous masses. The growth of the Alpine chain was not, as formerly supposed, an *exogenous* one—resulting from the successive deposition on the flanks of a granitic axis of layers of gradually less crystalline character—but an *endogenous* one; masses of pre-formed sediments being upheaved along certain lines, and at the same time folded, crumpled and crushed, while they had a crystalline structure induced in them and liquefied masses from below thrust into their midst. So recent, geologically speaking, have been those manifestations of subterranean force to which the Alpine system owes its origin, that the greater part of the present elevation of these seemingly "everlasting hills and perpetual mountains" is unquestionably due to causes which have operated since the period of the deposition of the clays and sands *on which London is* built!

It is not our purpose to discuss in these chapters the general phenomena connected with the formation of the Alpine chain. This has recently been done in a most able manner by Professor Suess of Vienna, in his "Die Entstehung der Alpen." Our object will be rather to study the relations between the manifestations of subterranean force which have, during such comparatively recent geological periods, resulted in the striking mechanical and chemical changes in the Alpine strata, and those others which have produced the numerous volcanic outbursts within and around the Alpine system. And we believe that these studies of the orographic features of our own continent will lead us to conclusions, similar to those arrived at by Darwin from his observations in South America—namely, that the causes of the elevation of continents and of the upheaval of mountain chains are but different modes of action of the same forces which give rise to volcanic outbursts.

We must here, however, carefully guard ourselves against an error into which some of the older geologists fell. Although the elevation of surrounding areas often precedes and accompanies the outbursts of volcanic forces, and the actual accumulation of ejected materials around igneous vents may result in the formation of mountain piles of the vastest dimensions, yet the origination of the principal mountain chains does not appear to be *directly* referable to volcanic action. On the contrary, a period of volcanic activity in a district would seem to be almost invariably followed by a greater or less amount of subsidence of the immediate area in which it takes place. Von Buch, when he came to study the interesting volcanic rocks situated in the very heart of the Alpine chain—namely, those of the Southern Tyrol—fancied that he had discovered in them the real cause of the elevation of the Alps. The fallacy of the views of Von Buch has, however, been fully shown by the proofs which have been since obtained, that the volcanic eruptions in question took place at a period long prior to that of the movements to which the origin of the Alps must be attributed.

But although the outbursts of these volcanic rocks of the Southern Tyrol were certainly not the *direct cause* of the elevation of the Alpine chain, it would be a great error on our part to hastily adopt the conclusion that the two series of events had no connexion with one another.

So far as we are able to judge from the characters of the faunas of the Silurian, Devonian and Carboniferous rocks of Southern Europe, there is no reason whatever for concluding that during these periods any kind of barrier to the distribution of organic life occupied the position of the existing Alpine chain. Indeed, the first indication of the existence of a line of weakness in this portion of the earth's crust is found towards the close of the Permian period, when a series of volcanic outbursts on the very grandest scale took place, along a line parallel to and nearly coincident with the main axis of the present Alpine range, and were continued with some interruptions till nearly the close of the Triassic period. Of the nature, products, and attendant phenomema of these pre-Alpine volcanic outbursts, we propose to give a slight sketch in the present chapter.

In studying the history of these early outbursts of the volcanic forces in the Alpine district, we have unfortunately some great difficulties to contend with. Throughout the greater part of the Alpine range, sedimentary rocks of younger date have been piled to the height of many thousands of feet above the volcanic products of the period we are considering. At three points, however, denuding forces have exposed them for our study—namely, near the Lake of Lugano on the borders of Switzerland and Italy, in the Southern Tyrol, and in the country about Raibl in Carinthia. At a number of intermediate points and at some others in the same line, but to the eastward of all of them, more partial exposures of volcanic rocks of contemporaneous date are found; these serve to indicate that, if we could remove the mass of superincumbent rocks of later date, we should probably discover beneath them a continuous range of volcanic masses along a line nearly coincident with that of the future Alps.

Of the several exposures of the pre-Alpine volcanic rocks, that which affords us by far the best insight into the nature and succession of the operations which took place, occurs in the district of the Southern Tyrol. The old volcanos of this country we shall now proceed to describe, and then afterwards briefly notice the features of some of the contemporaneously formed igneous masses at other parts of the Alpine system.

The greatest breach in the continuity of the Alpine chains is that which has been effected by the denudation of the river-systems of the Inn and the Adige, flowing northwards and southwards to the Danube and Po respectively; and it is at the watershed between these two systems of valleys that the lowest of the great Alpine passes—the Brenner—occurs. Now, it is just in this area of maximum denudation that the finest exposure of the pre-Alpine volcanic rocks is found.

The oldest of these is the well-known quartz-porphyry of Botzen, which by the earlier geologists was regarded as a granite. Although only very partially exhibited by the denudation of the vast overlying masses of the Triassic, Rhætic, Jurassic, Tithonian, Neocomian and Cretaceous rocks, it can be traced over an area of more than 1,000 square miles, and is found to constitute mountain-masses of more than 9,000 feet in height. It is probable, moreover, from the appearance of similar rocks at the bottoms of deep valleys, and at other points where the younger formations have been removed by denudation, that a belt of similar rocks extends below the southern limestone zone of the Alps, from the borders of Switzerland on the west to Carinthia in the east.

The rock of the quartz-porphyry of Botzen presents many variations in structure and appearance; while it sometimes approximates in its characters to the granites, with which class of rocks it was, as we have already remarked, identified by the older writers, it at other times closely resembles the recent Liparites of Hungary and other countries. The quartz is almost always distinctly visible, as more or less rounded grains, and these, with crystals of orthoclase felspar, are imbedded in a paste, which is sometimes micro-crystalline, at others more or less glassy, and occasionally exhibits a sphærulitic structure.

Closely associated with the quartz-porphyry of Botzen is a rock called by Tschermak "quartz-porphyrite," and which differs from the former principally in being composed of a *plagioclase* felspar instead of orthoclase. This rock is best seen in the San Pellegrino Valley lying to the south of the mountain of Monzoni, but it has also been detected at some other points in the district. It is usually of a greyish-green colour, and exhibits numerous large grains of quartz with smaller crystals of plagioclase felspar and biotite, imbedded in a compact dark-coloured base. The rock in question is of much interest as presenting us with an exact representative among the volcanic products of older date of the remarkable modern quartz-Andesites or Dacites, which are so largely developed in Eastern Europe. The view once held by petrologists, that the prevailing felspar in all rocks which contain free quartz must necessarily be an orthoclase, is now shown to be altogether untenable. Among granitic rocks we have the Tonalite of vom Rath (the so-called granite of the Adamello group), composed of a plagioclase felspar with much free quartz. Among the porphyritic rocks, or those with a texture intermediate between granites and lavas, and also among the latter class of rocks themselves, we find innumerable examples of rocks of similar mineralogical constitution,—both in the modern Hungarian Dacites and the ancient quartz-porphyrites of the Southern Tyrol.

With regard to the epoch at which these quartziferous lavas of the Southern Tyrol were erupted, all geologists are now agreed that it must have been that of the Dyas or Permian.

In order to illustrate the ultimate composition of these quartziferous volcanic rocks, which during the Permian period were so abundantly erupted in the Alpine region, we may cite the following analyses:—

	(1)	(2)	(3)	(4)	(5)
Silica, with Titanic acid	76·14	73·10	74·62	67·98	66·75
Alumina	12·69	12·84	11·94	14·01	16·53
Peroxide of Iron	—	—	—	—	2·76
Protoxide of Iron	1·78	3·02	2·59	5·00	1·66
Protoxide of manganese	0·17	trace	0·23	—	—
Lime	0·51	1·22	0·73	2·47	4·71
Magnesia	0·32	0·44	0·31	2·41	2·64
Potash	5·81	4·32	5·29	3·55	1·82
Soda	1·82	3·33	2·93	2·25	2·86
Water	1·03	1·20	0·90	1·67	2·12
Totals	100·27	99·47	99·54	99·34	101·85

(1) is a typical example of the quartz-porphyry of Botzen from St. Ulrich in the Grödener Thal. The analysis, which is by Dr. Ruhe, was published by Scheerer.

(2) and (3) are analyses of somewhat similar rocks made by Scheerer and Ruhe respectively; (2) is the rock of Moena, which contains much pinitoid.

(4) is a rock, which is regarded by Tschermak as to a certain extent intermediate in character between the quartz-porphyries and the quartz-porphyrites. It is from the Travignolo Valley, and the analysis given is by Scheerer.

(5) the interesting quartz-porphyrite from the San Pellegrino Valley. The analysis, which is by S. Konya, was published by Tschermak.

With respect to the mode of formation of these vast masses of volcanic rocks in the Southern Tyrol, the only conclusion at which we can arrive is, that the highly siliceous materials which compose them constituted a lava of only very imperfect liquidity, and that, like many modern lavas of the same class, it quietly welled forth from volcanic fissures, building up vast dome-shaped mountains, the formation of which was attended with but comparatively little explosive action. Masses of tuffs, however, clearly resulting from the latter kind of action, do occur in association with these widely spread quartziferous lavas, and the manner in which they are found to alternate with beds of sandstone and conglomerate, as in the Grödener Thal, and at many other points, indicates that the outbursts by which these volcanic rocks were formed must have taken place either on the land or in shallow water. Richthofen has endeavoured to refer these Permian volcanic outbursts to a number of distinct periods, and it is certain that they must have extended over enormous intervals of time. Some idea of the scale on which these displays of volcanic activity took place may be gathered from the fact that, although they were certainly greatly denuded before the deposition of the superincumbent rocks upon them, and are now only very imperfectly exposed to our observation, yet the quartziferous volcanic rocks of the Botzen district constitute rock-masses more than 9,000 feet in thickness!

The eruption of the quartz-porphyry of Botzen, which, as we have shown, must be regarded as the first symptom of the existence of that line of weakness in the earth's crust, to which the formation, at a later period, of the Alpine chain must be ascribed, was followed by a prolonged period of subsidence. During this epoch the vast thickness of sediments which constitute the Alpine Trias was deposited, consisting of sandstones, limestones, and shales piled upon one another to the aggregate thickness of several thousands of feet. This quiet accumulation of sediments during the Triassic period was, however, interrupted by a number of volcanic outbursts on a far less grand scale than those which had taken place during the Permian period; the remarkable variations in the thickness and mode of formation of the several divisions of the Alpine Trias also indicate the very local and interrupted nature of the movements which were taking place in the area, and prove the continued activity of those subterranean forces of which the manifestations at the surface by volcanic outbursts had become so much more feeble.

If, however, the volcanic outbursts of the Trias appear insignificant in extent when compared with those of an earlier period, they arrest the attention of the geologist much more powerfully than the latter, on account of the variety and interesting characters of the rock-masses produced by them; and especially by the assemblage of beautiful crystallized minerals, which have resulted from the action of the igneous intrusions on the surrounding stratified masses.

There are indeed few localities in Europe more justly famous among men of science than the valleys of the Southern Tyrol. To *those of the most* varied tastes, the district offers equally powerful charms. The artist and lover of picturesque scenery is attracted by the remarkable contrasts afforded by the dark rugged igneous masses, surrounded by spires and precipices of glittering dolomite; the botanist finds a wonderfully varied flora growing upon its strangely diversified soils; the mineralogist recognizes it as an almost unrivalled locality for many beautiful crystallized forms; the palæontologist knows of no richer hunting grounds than the beds of St. Cassian; the granites and porphyries of the area are among the best-known types of the petrologist; and the physical geologist has learnt to regard it, ever since the days of von Buch, as a field in which a solution of some of the grandest problems of his science may be hopefully sought. Few districts of equal area can, perhaps, boast of a scientific literature so prolific; and a list of works relating to its geology alone, which was drawn up by Richthofen in 1858, and extends to ten quarto pages, would have to be very largely added to, in order to bring it up to date. The visitors' books of the little inns in the secluded valleys of the Southern Tyrol are collections of the autographs of scientific investigators; and nowhere perhaps in the whole world do the quiet and unobtrusive labours of men of science attract so large an amount of popular attention as in these remote valleys. The English geologist smiles to see in such a spot the portrait of Sir Roderick Murchison, of course well be-starred and be-ribboned, paired with that of Alexander Von Humboldt, and both placed as supporters to the picture of an Austrian Archduke, whose name was given to a well-known mineral species. So great is the interest excited by the remarkable rocks of this district, and especially by those of Monzoni and Predazzo, and so various at the same time are the conclusions at which different students of them have arrived, that we may well call this region "the battle-ground of Petrologists."

There are a number of different centres of eruption which can be traced by an attentive study of the Triassic rocks of the Southern Tyrol. From most of these great quantities of agglomerates, tuffs and ashes were ejected, which have formed immense deposits in the midst of the Triassic series, and from most of them lava either of the type of augite-porphyry or melaphyre also flowed. Two of these centres of eruption, however, those of Predazzo and Monzoni, are of especial interest, from the numerous and interesting varieties of igneous rocks which they poured forth. The name of "crater," which has been applied to some of the centres of eruption by Richthofen, is an unfortunate and misleading one, for nothing can be more certain than that the different cones and craters have had their original forms entirely destroyed by denudation, and that the remarkable cup-shaped arrangement presented by the strata around each of these points of volcanic action is due, as we shall hereafter see, to a totally different cause from the explosive action that forms true volcanic craters.

The period of the formation of these several volcanic vents is that of the Upper Trias. This was conclusively shown by Richthofen, whose well-known work on the district, published in 1858, was the result of many years of patient study, and will hold its place (however much some of its minor conclusions may be modified by later investigations) as one of the most remarkable and valuable of geological monographs. A more recent and very able investigator of the district, Dr. Doelter of Vienna, finds evidence which leads him to refer all the eruptions of the area to that portion of the Upper Trias known as the "Wengener Schichten."

Among the several varieties of volcanic rocks produced at the two interesting vents of Predazzo and Monzoni, a definite order of appearance has been recognized by all geologists who have investigated the subject. This succession is as follows:—

1. Monzonite, including under this name the Hypersthene and Diallage rocks, the Diabase or Pyroxene Monzonite, the Monzoni- or Augite-syenite, and the Amphibole Monzonite.
2. Tourmaline-granite.
3. Melaphyre, with Augite-porphyry, Uralite porphyry, and the tuffs associated with these several rocks.
4. Orthoclase porphyry (porphyrites and syenite-porphyry of Richthofen).

It will be interesting to notice, in the first place, the nature and composition, both chemical and mineralogical, of these several volcanic products; then to point out the relations to one another and to the sedimentary rocks of the masses which they constitute; and lastly to seek to determine the exact conditions under which they were formed.

The Monzonite, which was known to the older writers on geology as "the granite of Predazzo," is a rock of unmistakably granitic structure, although its volcanic origin is also equally clear and indisputable. Under the general term have been included the two rocks distinguished by Richthofen as Monzoni-syenite and Hypersthene-rock, by Tschermak as Monzoni-syenite and Diabase, by vom Rath as Augite-syenite and Diabase, and by Doelter as Pyroxene-Monzonite and Amphibole-Monzonite.

The Monzonite would appear never to contain free quartz, but it seems to me, from the examination which I made of the celebrated mountain of Monzoni, to present every gradation between a rock of decidedly acid character on the one hand to one of the most eminently basic description on the other. Sometimes it is found to consist almost entirely of an aggregate of orthoclase crystals, with a small quantity of a plagioclase felspar, of biotite and of a pyroxenic constituent. It is a singular circumstance that the last-mentioned ingredient presents some very remarkable peculiarities of character, that render it very difficult to determine its exact nature. Tschermak regards it as a *hornblende*, while vom Rath considers it to be an *augite*, and in consequence calls the rock "augite-syenite."

In other varieties of the rock, however, we find the orthoclase occupying a gradually less conspicuous place, and finally disappearing altogether; while the plagioclase felspar (usually labradorite), the biotite and the pyroxenic constituent (which in the more basic varieties of the rock, though regarded at first by both De Lapparent and Des Cloiseaux as a hornblende, is now pretty generally accepted as augite), constitute the whole mass. Sometimes the augite is replaced by diallage or hypersthene, and occasionally the felspathic ingredient almost wholly disappears, and we have an augite-, diallage-, or hypersthene-rock.

In illustration of the ultimate composition of the varieties of the celebrated Monzonite-rock, we may cite the following analyses:—

	(1)	(2)	(3)
Silica	58·05	50·80	38·18
Alumina	17·71	16·20	10·06
Peroxide of Iron	—	—	17·50
Protoxide of Iron	8·29	14·37	9·47
Lime	5·81	10·00	11·84
Magnesia	2·07	3·53	9·72
Potash	3·24	3·90	1·38
Soda	2·98		0·52
Water	1·34	1·20	1·26
Totals	99·49	100·00	99·93

(1) is the analysis of a typical Monzoni-syenite (Augite-syenite of vom Rath) by Kjerulf. The specimen was obtained from the Margola near Predazzo.

(2) and (3) are analyses of more basic rocks (diabase or pyroxene-Monzonite) of the Canzacoli near Predazzo. (2) is an analysis by Delesse; (3) by Konya, as given by Tschermak.

The "Tourmaline-granite" is, like the Monzonite, a rock of truly granitic structure, although now universally regarded as of volcanic origin. It is a well-marked granite of a red colour made up of orthoclase of a more or less deep pink tint, white or greenish plagioclase, grey quartz and biotite. But in addition to these minerals we find, and generally in association with the quartz, considerable quantities of tourmaline, forming masses of radiating crystals sometimes of large size. The drusy cavities, which sometimes occur in the rock, frequently contain various beautifully crystallized minerals.

The following analysis of the Tourmaline-granite of the Mulatto near Predazzo, which was made by Kjerulf, will serve to illustrate its ultimate composition:—

Silica	70·73
Alumina	14·16
Peroxide of Iron	3·59
Lime	1·03
Magnesia	0·66
Potash	5·37
Soda	2·54
Loss	1·10
Total	99·24

Tschermak regards this rock as essentially composed of 30 per cent. of Quartz, 32 of Orthoclase, 27 of Oligoclase, and 10 of Tourmaline.

The next rocks, taken in the order of their appearance, are those which von Buch and the earlier writers spoke of as black-porphyries and basalts; they are now classed as Melaphyres, Augite-porphyries and Uralite-porphyries. The so-called Melaphyres consist principally of plagioclase felspar with occasionally a little orthoclase, augite, olivine (usually in a much altered condition) and magnetite. Except on the ground of their age, there appears to be no reason whatever for removing them from the basalts. Sometimes the rock becomes porphyritic in structure, from the diffusion through it of large plagioclase crystals; at other times the whole mass becomes coarsely granular, and has been classed as a diabase, though it should probably be more properly called a dolerite. When the rock contains large crystals of augite scattered through it, it becomes an augite-porphyry, and where (through alteration, as Tschermak shows) these augite crystals present the Uralite modification, the rock passes into uralite-porphyry. All these basic rocks graduate into one another, they frequently assume an amygdaloidal structure, and are associated with enormous masses of agglomerates, tuffs and ashes of similar composition. The chemical constitution of these rocks is illustrated by the following mean analyses as calculated by Tschermak from the closely approximating results arrived at by a number of different chemists.

	Melaphyres.	*Augite-porphyries.*
Silica	53·01	49·78
Alumina	17·05	18·83
Protoxide of Iron	11·95	11·47
Lime	8·27	10·44
Magnesia	3·77	4·87
Potash	3·42	2·65
Soda	2·56	2·05
	100·00	100·00

Of still younger date than the basaltic rocks just described are others of restricted distribution, which Richthofen called Syenite-porphyry and Porphyrite, but which are by Dr. Doelter classed as Orthoclase-porphyry. They are coarse-grained rocks of porphyritic, occasionally approaching to granitic structure, consisting of a granular or felsitic base in which twinned crystals of red orthoclase, with hornblende and magnetite, are scattered. This rock, like portions of the Quartz-porphyry of Botzen, often contains considerable quantities of the mineral of the pinite group known as Liebnerite. We subjoin the following analysis by Kjerulf in illustration of the ultimate composition of the Orthoclase porphyries:

Silica	59·17
Alumina	19·75
Protoxide of Iron	1·71
Lime	3·92
Magnesia	0·40
Potash	4·03
Soda	3·54
Water, Carbonic Acid, etc.	6·94
	98·43

We have dwelt at considerable length on the petrological characters of these old volcanic masses of the Southern Tyrol, because of the great amount of attention which they have attracted among geologists ever since the days of Von Buch, and the lively discussions of which they have been the subject. They are interesting

), as presenting us with rock-masses of the most perfectly granitic
ucture, of which the volcanic origin is certainly not open to
ibt; this will at once appear when we come to notice their rela-
ns to the sedimentary rocks; I am not indeed aware that the fact
been ever disputed by any competent observer. We will now
ceed to notice some of the more salient features of the structure
l relations of these igneous rocks, which serve to throw light on
questions of their age and mode of formation.

As already mentioned, the whole of the smaller and scattered
lcanic outbursts in the Southern Tyrol took place during the
riod of the Upper Trias. This is proved in the most conclusive
nner, by the way in which the igneous rocks are only found
rusive among the lower members of the formation, while their
fs are interstratified with the beds of its higher members. Ac-
rding to Dr. Doelter's most recent researches, as we have before
inted out, all the eruptions must have taken place during the
riod of the formation of the "Wengener Schichten." In the
trict which denudation has exposed to our study, we find, as
eady remarked, a number of different centres of eruption, most
which however have only produced rocks of basaltic character,
laphyres with Augite- and Uralite-porphyries. But two of these
itres of eruption are of larger size and more complex structure,
t of Predazzo having emitted the whole of the interesting varieties
rocks we have noticed in the preceding pages, and that of Mon-
i all except the tourmaline-granite.

The Monzonite rises in great intrusive masses through the midst
he limestones and other rocks of the district, which assume, for a
siderable distance around, a highly crystalline character. Some-
es, as at Monzoni, vast masses of the metamorphosed limestone
seen to be actually entangled and inclosed in the midst of the
eous rock. Concerning the relations of the two varieties of
nzonite to one another, very various opinions have been expressed
different observers. Richthofen regarded the more basic portions
the rock, to which he gave the name of "hypersthene-rock," as
versing the Monzoni-syenite, which constitutes the larger part of
mass, in veins. But although such veins of the basic variety of
rock do occur traversing the more acid kind, as is well seen in
Margola near Predazzo, yet the observations of Dr. Doelter
n Monzoni would appear to lead to the conclusion that the great
sses of rock with plagioclase felspar are not sharply divided
m those in which orthoclase is the predominant constituent.
leed, as I have before observed, it is possible to find at Monzoni
ry possible gradation, from the most acid to the most basic variety
the rock.

The Tourmaline-granite, which is seen only near Predazzo, also
s in great intrusive masses, which traverse the Monzonite, and
d off veins into it; so that there can be no doubt as to the more
ent date of its eruption.

The Augite-porphyry, Uralite-porphyry, and Melaphyre consti-
e intrusive masses rising through the Monzonite and the Tourma-

line-granite and giving off veins which traverse both of these rocks. These basaltic rocks are, as already stated, by far the most widely distributed products of the volcanic ejections of the Trias period in the Southern Tyrol, and are found at all the centres of eruption.

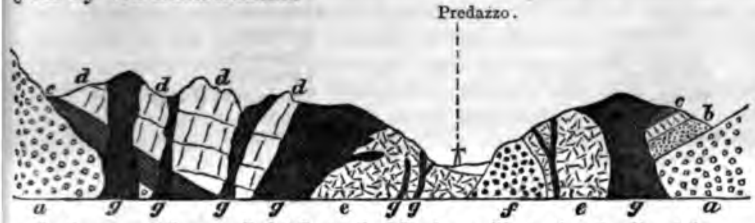
The last-formed of these Triassic volcanic rocks are the porphyrite and syenite-porphyry of Richthofen (the orthoclase-porphyry of Dr. Doelter), which, however, only occurs in the form of veins traversing all the other rocks, but does not constitute any considerable proportion of the intrusive masses.

From the peculiar arrangement affected by the stratified rocks around the different centres of eruption, Richthofen, as we have already seen, applied to them the name of "craters." It must, however, be clear to every one who carefully examines the question that the actual volcanic cones, and therefore the craters themselves, must have been destroyed by denudation before the deposition of the highest beds of the Trias. It seems to be certain, from an examination of the tuffs produced by them, that the eruptions of this period must have taken place under the waters of a comparatively shallow sea, and that the cones, as they were built up, gradually rose to the surface, when (as in the well known case of Graham's Isle) they would be gradually destroyed, and their materials distributed by the waves. Near the centres of eruption we find the coarsest agglomerates containing bombs and ejected masses of the surrounding sedimentary rocks; but as we recede from these centres the ejected materials become of gradually finer character, and more mingled with aqueous sediments. In the latter condition they are often seen to be crowded with the beautiful fossils of the St. Cassian series, and alternate with other beds of the "Wengener Schichten."

Although it cannot be proved that the Monzonite-rock and the Tourmaline granite actually reached the surface, yet it is in the highest degree probable that they did so. They certainly could not have formed extensive lava-streams, nor have given rise to any great quantity of tuffs by explosive action; indeed we are unable to determine exactly the form which these particular granitic rocks would assume on reaching the surface. Their composition is, however, identical with that of certain sanidine-trachyte and andesitic lavas. Probably, after the manner of many lavas of this class (such as the Domites of the Auvergne), they constituted very imperfectly liquid masses, which quietly welled forth, forming dome-shaped hills, the extrusion of which was accompanied by but little explosive action.

Very different, however, must have been the phenomena attending the eruption of the more basic rocks,—the so-called melaphyres, augite-porphyries, and uralite-porphyries. Not only do these appear to have flowed from the igneous centres in lava-streams of considerable length and thickness, but the explosions which accompanied them certainly gave rise to the formation of the most prodigious quantities of scoriæ and ashes. From the study of these vast deposits we obtain the clearest insight into the conditions under which the volcanic outbursts to which they owed their origin must have taken

An interesting circumstance with regard to the relations between these great intrusive masses, which formed the centres of old Triassic volcanos, and the sedimentary rocks by which they are surrounded, was first pointed out by Leopold von Buch, and regarded by him as being altogether inexplicable, as indeed, if his theory of "elevation-craters" were true, it certainly would be. This is the constant dipping of the stratified rocks around the different igneous centres, not *away* from them, as we might at first be led to imagine would be the case, but *towards* them. This fact is very clearly exemplified at Predazzo, as the accompanying section, which has been derived from one of those published by Richthofen, will show; and it was also very clearly represented in the earliest sections of the district given by von Buch himself.



Section across the so-called "Crater" of Predazzo, illustrating the dip of the stratified rocks towards the centre of eruption.

a Botzen porphyry (Permian).
b Lower Trias.
c Middle Trias.
d Upper Trias.
(*b*–*d*) Sedimentary rocks.
e Monzoni-syenite with "diabase" veins.
f Tourmaline granite.
g Melaphyre.

That these singular cup-shaped depressions of the strata around each of the volcanic centres in the Southern Tyrol can have no claim whatever to be called "craters," in the ordinary sense in which geologists use that term, we have already remarked. The true explanation of the phenomena presented by them is to be found in a fact, first pointed out by Darwin, but of which illustrations have since been found in many widely separated volcanic districts—namely, that the ejection of volcanic materials at any point is liable to be followed by subsidence of the rocks around it. I have elsewhere shown how very frequently this kind of action takes place, and what beautiful illustrations we have of it even in our own islands. From my study of the rocks of the Southern Tyrol it appears to me to be perfectly clear that, after the cessation of volcanic activity at the numerous small centres of eruption, the central mass must, in almost every instance, have subsided before the denuded ruins of these old volcanos were buried under the later deposits.

Perhaps, however, the most interesting circumstance of all connected with these old volcanic outbursts is the insight which they afford as to the mode of origin of those beautifully crystallized minerals which are so frequently ejected from the craters of active volcanos, like Vesuvius, or are found among the agglomerates and tuffs of extinct ones like the Laacher See. There is probably no locality in the *whole world which* has yielded so large a number of mineral species as the flanks of Vesuvius and the cliffs of Somma; and as second only to it we may probably rank the mountain of Monzoni. Strange to say, the species and varieties of minerals found at these two localities have very much in common. This will be clear to any one who is acquainted with the ordinary Vesuvian minerals, and will compare the following list of those which have been obtained at Monzoni.

Minerals of Monzoni.

*Augite.
*Fassaite (pseudomorphs after Monticellite.)
Sahlite (Pyrgom).
Epidote (Pistacite).
†Garnet (Grossular).
*†Spinel.
Pleonaste.
Ceylandite.
†Vesuvian.
†Gehlenite.
Mica.
*†Biotite.
*Wollastonite.
Orthoclase (Adularia).
Anorthite.
Labradorite.
*Brandisite.
Scapolite.
*Monticellite (Batrachite).
*Serpentine.
*Vorhauserite.
†Gymnite.
Axinite.
Zircon.
*Titanite.
Prehnite.
Chabasite.
Laumonite.
Thomsonite (Comptonite).
Apatite.
†Brucite.
Quartz.
Calcite.
*Magnetite.
Specular Iron.
Iron Pyrites.
Copper Pyrites.

The species marked * are most usually found in connection with the more basic varieties of the Monzonite, those with the † more commonly occur near the acid varieties of the rock.

At first sight, no localities would appear to offer greater points of dissimilarity than the lava slopes of Vesuvius and the dark rugged granitic mass which rises in the very heart of the brilliant white pinnacles of the far-famed Dolomite Mountains; and yet, as we shall proceed to show, there is much in common between them, and only a slight examination of the question will be necessary to convince the observer that the beautifully crystallized minerals have in both cases been formed under identical conditions.

The interesting minerals of Vesuvius are found, as every mineralogist is aware, by breaking up the blocks of limestone (which have been blown from the crater, especially during certain eruptions, or which are found in the agglomerates of Somma, the products of older outbursts), and the crystallized minerals are seen lining their cavities.

The volcano of Vesuvius has been opened through the midst of masses of Subapennine-limestone, and it is in the metamorphosed fragments of the rock, evidently torn from the sides of the vent, that the minerals in question are found. The formation of these minerals is clearly due to the contact of masses of igneous rock, charged with imprisoned water and various gases, with the masses of limestone they have penetrated, and to the play of those chemical and crystal*lizing forces,* which under these remarkable conditions are called *into being.*

Now the exquisite products which Nature has, at Vesuvius, exported from below and duly delivered at the surface, by the transporting power of steam, may be examined by us at Monzoni, still lying in the workshop in which they were elaborated. In the case of Vesuvius, volcanic explosions have brought the minerals to us, but in that of Monzoni denudation has enabled us to penetrate to their birthplace; and in the very heart of this old volcano, now cold and dead, the geologist may study the products of operations similar to those which are doubtless taking place, far below the surface, in the case of vents which we still see in activity around us.

The various localities for the beautifully crystallized minerals of Monzoni all appear to be situated at the junction of the igneous rocks with the limestone masses, through which they have burst or which are in some cases entangled in them. It has also been shown, as indeed we might have anticipated, that the species of minerals produced at the planes of contact of the limestone with the more basic igneous rocks (hypersthene and diallage rock, diabase or pyroxene monzonite) are different from those which have originated at the junction surfaces of the more acid rocks (the Monzoni- or augite-syenite). We have indicated in our list of minerals those which are usually found near the masses of basic rock, and such as occur in proximity to the more acid ones respectively.

In not a few cases, as might be expected from the great age of the deposits in which they lie, and the vast series of changes to which they have been subjected, some of the minerals have been converted into pseudomorphs. And on the same ground we may easily account for the absence of all those more unstable mineral products which are found at Vesuvius and other active volcanic vents. We have the clearest proof that the volcano of Monzoni, and the other contemporaneous ones of the Southern Tyrol, have gone through a precisely similar series of changes to that which has befallen our own old volcano of Arthur's Seat, and many similar ones in Central Scotland,—namely, that they have first been buried under many thousands of feet of younger strata, and that subsequently, by the upheaval and denudation of these, they have been once more exposed to view at the surface. To a recently published memoir of vom Rath we are indebted for much new and most valuable information concerning the nature and mode of origin of the minerals of Monzoni. I need not in this place do more than refer to the similarities of the varieties and manner of occurrence of these beautiful minerals of the Tyrol with those which I have described as occurring among the ancient volcanos of the Highlands.

We have now shown how, through the accidental removal by denudation of the overlying rocks of the Southern Tyrol, the fact has been revealed to us that during the Permian period enormous masses of volcanic rock (identical in character with the modern Liparites and Dacites) were erupted along a line nearly coincident with that of the subsequently formed Alpine Chain; and that these grand outbursts—which led to the formation of volcanic mountains at least 8000 to 9000 feet in height—were followed after an interval by the opening of a number of sporadic vents in the same district. We have also pointed out that both to the eastward and westward of the region which we have been more particularly describing, and evidently constituting part of the same linear series of contemporaneous eruption, we find, wherever the superincumbent rocks have been removed by denudation, similar evidences of volcanic action taking place prior to the formation of the Alpine system.

In concluding this chapter we shall enumerate and very briefly describe the principal exposures of the products of this old line of volcanic action.

On the shores of the Lake of Lugano there occurs a tract occupied by igneous rocks, which are shown, by their relations to the sedimentary masses of the district, to have been erupted after a portion of the Permian strata were deposited, and before the great mass of the Triassic rocks were formed. These igneous rocks appear to consist of great masses of quartz-porphyry, very similar to that of Botzen, with smaller and subordinate outbursts of porphyrite and melaphyre. Some masses of truly granitic rock appear in the same district, which may also perhaps belong to the same age. The general resemblance of these rocks of Lugano and Ticino with those of the Southern Tyrol is very striking; and, were we able to remove the masses of younger strata which cover almost the entire country between these two districts, we should probably find the two areas of igneous rocks to be parts of the same continuous series. Indeed, at more than a dozen intermediate points, the widely-spread Permian quartz-porphyries have been detected in the bottoms of deep valleys, and wherever the newer rocks have been cut through by denudation.

Passing *eastward* from the grand exposures of the pre-Alpine volcanic rocks, we find them again making their appearance in the country about Raibl in Carinthia. The beautiful red quartz-porphyry of this locality (containing 76 per cent. of silica) is associated with volcanic tuffs, and rocks of more basic character; there is the clearest evidence that these rocks were erupted at the same period as those of the Southern Tyrol and Lugano. Isolated exposures of the same rocks have also been detected at a number of other points in Carinthia.

Still farther in the same direction, and where the Alpine chain sends off its two great eastern branches, namely, the Carpathians stretching to the north-east, and the Julian Alps extending towards the south-east, we find masses of eruptive rock of the same age as those we have been noticing. Such are the various igneous masses of the Island of Lissa and other points in Dalmatia, and the melaphyres of Waag, which are of Permian age, with others at several points in the Carpathians and Transylvania, which were erupted at intervals during the Trias and part of the Lias period. The occurrence of all these igneous masses would seem to indicate that, not only was there made manifest at the close of the Permian epoch the existence of a line of weakness in the earth's crust, nearly coincident with the great central Alpine mass, but that the principal fractures radiating from it must have been already even at this early period determined.

In several future chapters we shall endeavour to trace the successive manifestations of the volcanic forces in the same area, and to show their relations to the tremendous exhibitions of force resulting in those grand movements by which the Alpine rocks have acquired their present positions and relations.

P.S.—I am indebted to my friend, Prof. vom Rath of Bonn, for calling my attention to an error into which I have fallen in the last chapter of this series. On page 54, I have classed the gaseous exhalations of the Büdos Hegy in Transylvania with those of the Solfatara, as having an elevated temperature. This is not the case, however, the gas evolved at the former locality having the same temperature as the surrounding atmosphere.

(*To be continued.*)

IV.—SOME CONSIDERATIONS ON THE PROBABLE CONDITIONS UNDER WHICH THE PALÆOZOIC ROCKS WERE DEPOSITED OVER THE NORTHERN HEMISPHERE.

By HENRY HICKS, F.G.S.

(*Continued from page* 160.)

Upper Silurian.—At the close of the Lower Silurian, as already stated, changes of considerable importance took place in some of the areas which had undergone depression. The sea-bottom was now raised in parts of Western Europe, and in North America, and islands of some extent formed. In Europe the most important were those in North Wales, Shropshire, Cumberland, the South of Scotland, and in Nassau. It is probable also that one or more extended along Southern Europe, from Portugal into Spain, etc., but the evidence concerning this is as yet imperfect. In America, according to Logan, Dana, etc., the principal parts raised at this time were the Green Mountain regions, and the ridge extending from Lake Erie over Cincinnati into Tennessee. These American ridges appear to have been raised to a great height, and to have remained afterwards in part dry land, even to the close of the Palæozoic. The islands in Europe were raised only to a small height above water-level, and were probably all again submerged by the close of the Upper Silurian. The uplifting did not take place in Britain until after the close of the Bala period, or after the Upper Bala Limestone had been formed over the British area. The changes may be said, therefore, to have taken place when the Lower Llandovery rocks were being deposited over the parts still submerged. The uplifting in Europe occurred chiefly in regions where volcanic action had previously taken place, and the changes seem to have been produced on the whole rapidly. For instance, in Wales the upheaval, and a subsequent depression of most of the upheaved parts, must have taken place during the time that the Lower Llandovery rocks were being deposited in the surrounding sea, for in many places the Upper Llandovery rocks may be now seen resting on the upturned edges of the Lower Silurian beds. Again, as the Lower Llandovery rocks appear to have been made up for the most part from the denudation of these islands, where an abundance of loose material was ready at hand, it is evident that the change must have been on the whole rapid, and that a depression of the crust even in those parts again soon followed that of elevation. The elevation, as already stated, occurred only over a very small proportion of the Northern Hemisphere, compared with that in which depression was going on. The subsidence also in the larger areas continued to go on uninterruptedly at this point, and we find therefore that the beds which can be considered in any way the equivalents of the Lower Llandovery rocks of Wales in these undisturbed areas are very insignificant, and usually have no well-defined boundary.[1] I know that the generally received opinion is that these changes took place very gradually; but I think the above evidence tends strongly to show that elevation as a rule was rapid, compared with that of depression; and I further believe that it was so in all the changes which took place up to the close of the Palæozoic. The sediments which make up the earlier Upper Silurian rocks in the neighbourhood of the uplifted parts are such as would result from the denudation of these, and hence all conditions may be seen from those of beach pebbles to the very fine muddy sediment deposited at a distance from land. The Upper and Lower Llandovery rocks (including the May Hill Sandstones and Denbighshire Grits) show this clearly, and any variation in thickness or in composition is due to this cause. In the parts which remained submerged, as Pembrokeshire, Carmarthenshire, and probably Cardiganshire in South Wales, the sediments form a conformable series from the Lower to the Upper Silurian, whilst in the immediately disturbed areas an unconformity might be seen at any point up to the close of the Upper Silurian.

The higher groups in the Upper Silurian are made up of sediments, formed during periods in which a gradual depression of the sea-bottom was generally taking place. In Britain they are composed of an admixture of argillaceous material and of limestone. In the immediate regions of the parts at this time above water, but little limestone occurs, the rocks being made up almost entirely from the denudation of these islands. In France and Spain these groups are scarcely represented, but in Bohemia, Norway, Sweden, Russia, and in parts of Asia, they are represented chiefly by limestones. In North America by limestones, in the western and undisturbed regions, and partly by schists and sandstones along the eastern areas, or in the parts which had been disturbed at the close of the Lower Silurian (see Table, p. 156). The Upper Silurian period, therefore, was one of continued and gradual subsidence in apparently most of the European, and of the North American, and probably also of the Asiatic areas. The thickness of the series varied of course greatly in different regions, and the composition also, as we have shown, in proportion to the local changes which took place. The lines of depression recognized to have been marked in Cambrian times were not wholly obliterated in the Upper Silurian. The lines of migration of the faunas indicated in my former paper remained also apparently still to be the prevailing ones. The Cambrian and Silurian epochs seem to have been parts of the greater Palæozoic time, perfectly natural in their order of succession, and showing no signs of want in continuity when not interfered with by local changes. In Britain, as we have seen, the succession was checked in limited areas; but even here, generally, it cannot be said that any intervals of time are unrepresented by stratified formations, as supposed by some geologists. I would rather say that not only are all the lesser epochs represented in parts of this area (South Wales, etc.), the first or nearly so of all the European areas to become submerged; but that in addition, so far as sediments are concerned, some of the epochs here have an exaggerated importance from the presence of an excess of material derived from volcanos, and from the islands formed by the uplifted portions of the sea-bottom.

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[1] The following facts concerning the fossils, kindly communicated to me by Mr. Etheridge, F.R.S., strongly support this view of rapid deposition for the Llandovery rocks. Of the 143 species which occur in the Lower Llandovery in Britain, 17 only *can be said to* be restricted to that formation; and of the 236 species which have *been found in the* Upper Llandovery, 47 only are peculiar to that series.

Devonian and Carboniferous.—The physical conditions of these later epochs of the Palæozoic have been so frequently and so fully treated of by such eminent authorities as De la Beche, Sedgwick, Murchison, Ramsay, Prestwich, Etheridge, Geikie, etc., in Europe, and by Logan, Dawson, Dana, etc., in North America, that it will be only necessary for me to refer very briefly to them. The condition in the early part of the Devonian was like that at the close of the Upper Silurian, and the depression continued to go on regularly and uninterruptedly at this time in most parts of the Northern Hemisphere. It appears to have gone on persistently also to the close of the epoch in some areas, but in others about the middle, and from that to its close great changes took place, and the sea-bottom was there again raised above the sea-level. Volcanic outbursts also took place at this period, and a considerable amount of volcanic material was spread out, forming, in some places, islands in the sea, as between the Grampians and the Tay in Scotland, etc. The disturbances during this epoch, like those at the close of the Lower Silurian, occurred chiefly in the western areas in Europe, and along the eastern borders of North America. The differences which are now observable in the sediments belonging to this period in various parts were produced by, and hence dependent upon, the local changes that had taken place. In the undisturbed submerged regions limestones alone were formed, as in the previous epoch. Near the uplifted portions, sandstones and the usual materials to be derived from denudation, were deposited.

These changes gave an entirely new aspect to the Northern Hemisphere, and before the close of the epoch large areas of dry land and numerous lakes and inland seas extended in many directions. During the Carboniferous epoch, most of these areas were again depressed, and marine sediments very generally deposited. Where the-sea bottom remained undisturbed, as in South Wales, Devonshire, etc., the sediments belonging to these two epochs are perfectly conformable to one another; but in the disturbed areas an unconformity is of course shown. Because of the unevenness of the sea-bottom at the commencement of the Carboniferous epoch, it is difficult to estimate the amount of the depression which now took place; but since the sediments belonging to this period in some cases are as much as from 15,000 to 18,000 feet in thickness, it is evident that it must have been very considerable in extent. This period of gradual subsidence was followed again by great movements in the earth's crust, accompanied in many cases by violent volcanic action. Enormous areas were now upheaved to a great height, and mountainous ranges formed. The depression which had been gradually taking place over so large an expanse of the Northern Hemisphere seemed also at last to have reached its limit, and the land surface was now restored, partly in its proportion, though not in its general appearance, to the state it was in at the close of the Laurentian, or before the Cambrian rocks were deposited. Three periods of great disturbance occurred in Palæozoic time, and they were progressively more violent in their effects. Each also followed epochs of quiet and gradual depression, and they were most marked in the areas first submerged, where most sediment had accumulated, and hence where the pre-Cambrian crust had apparently become thinnest. The depression in some places for the whole of the Palæozoic could not have been less altogether than 50,000 feet, and conformable sediments to that extent are now found in some of the areas first submerged, and which remained undisturbed. In the south-west of Wales, where they attain this thickness, the same folds affect the whole series, from the Cambrian to the Carboniferous, and it is evident that in this region these deposits are all perfectly conformable to one another, though so near to the disturbed area of North Wales.

Along the eastern borders of North America (Appalachian region, etc.) the average thickness of conformable sediments, according to Hall, Dana, etc., is not less than from 40,000 to 45,000 feet; therefore the depression there must also have been nearly as great as that which took place in the western borders of Europe.

(*To be concluded in our next Number.*)

V.—CONCRETIONS.

By W. H. Penning, F.G.S.,
Of H.M. Geological Survey of England.

THERE is a fine exposure of the "Lower Greensand" in a railway cutting by Sandy Station on the G.N. and L. & N.W. Railways, presenting a nearly vertical section 50 or 60 feet in height. It consists almost entirely of clean sand, in parts false-bedded, and more or less coloured throughout by the presence of oxide of iron. The colour thus imparted to the sand varies from almost pure white, at the lower part, through shades of grey and yellow, to a deep rusty brown. There are here and there layers of hard ferruginous concretions in tabular, spherical, and many other forms, presenting a feature hitherto (so far as the writer is aware) unnoticed. This is a gradual passage from soft iron-stained sand to hard complete concretions, exhibiting the various *stages* in the process of their formation. This may be best observed toward the north end of the cutting, in immediate proximity to and generally beneath the patches of fully-formed concretions, but is visible also in other parts of the section.

The first step seems to have been the separation of the iron particles into very thin lines resembling stratification, followed by the union of two or more lines, by attraction or chemical aggregation acting on the iron. These thin layers of darker colour retain their true linear arrangement until about one-eighth part of an inch in thickness, when the space between them is reduced to about 3 or 4 inches, and they follow the lines of true or false-bedding as the case may be. They then begin to incline towards each other at intervals varying from four inches to a foot or more in length, and eventually the bent parts meet, thus enclosing irregular lenticular patches of light-coloured sand. This is as seen in section parallel to the line of cutting, but similar appearances would doubtless be presented in a transverse direction, and the lines of ironsand enclose small masses of material, from which the iron has been removed. In hardness and friability, and in all respects save colour, due to the presence or partial absence of iron, the enclosing and enclosed portions are the same, and the mass can be scraped with equal readiness throughout. But the darker shell gradually hardens and thickens by further elimination of iron from the neighbouring sand, both within and around it, but mainly from within, for the harder the shell has become, the lighter in colour is the nucleus, until it is found almost a pure white in the complete concretion.

These concretionary lumps may be seen in every stage, and in gradations of every stage—in the earlier the sand presents no alteration except a slight change in colour, then the shell hardens somewhat and stands out slightly from the face through weathering. It becomes harder still, and some force is required to break it; lastly it passes into its hardest and thickest form when it can be broken only by the hammer, and when it has removed all iron from the nucleus, leaving it perfectly soft and white.

The white central portion occurs in many forms, from a perfect sphere to a flattened lenticular lump, sometimes it fills a pipe of the hard ferruginous sand by which two larger masses have been connected. It would not have been possible for these rounded masses of white very loose sand to have been deposited as such, and for the iron-stained sand to have aggregated round them—moreover, the hard dark case is of a fairly uniform thickness, which would have been equally impossible under the circumstances. The white enclosed sand is loose from extraction of a portion of its original substance, and under a lens it is seen to consist chiefly of white quartz. There are some grains of the same mineral pink and yellow in colour, also occasional specks of a black substance which most probably is Glauconite.

This method of origination fully accounts for the hollowness of, [illegible] ironstone concretions, [illegible] peculiarities of many Chalk-flints. [illegible] nodular masses following [illegible] spheroidal and elongated [illegible] presenting odd corners and [illegible] aggregation around a [illegible] frequently filled with [illegible] have not been observed in [illegible] present characters similar [illegible]

NOTICES OF MEMOIRS.

I.—[illegible] DIVISIONAL STRUCTURE OF [illegible] SLATY CLEAVAGE. By [illegible] Professor of Mineralogy and Geology, [illegible] College, Galway. [illegible] of the Transactions [illegible] plates 34–38. [illegible]

THE “[illegible]” [illegible] of (pp. 606–612), [illegible] “cleat” of coal, chert, [illegible] Lepidodendron [illegible] and is regarded [illegible] rather than of the [illegible] rock-jointing are [illegible] of Jointing” [illegible]. The [illegible] jointings in some [illegible] others destitute of [illegible] (pp. 620–626), with [illegible] Geological Periods,” [illegible]; and Part II., [illegible] with some notes, con[illegible] a wide area of bare [illegible] (pl. 34), and [illegible] referred to (pls. 35–38), illustrate the Memoir.

The author alludes to the former communication of his views on the [illegible] of joints and cleavage in [illegible], and now treats of his [illegible] in which he has been aided by a grant from the Royal Irish Academy. Observations and opinions of others on the [illegible] subjects of jointing and cleavage are carefully alluded to, and [illegible] given in full.

In this Memoir, Prof. W. King, of Galway, urges the existence of universally distributed divisional planes, or joints, in a great variety of rocks constituting the earth's surface. He regards the joints as having been originally, and still often remaining, vertical; and as having either a more or less “meridional,”[1] or a more or less

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[1] [illegible] “[illegible]” throughout in the original; but this modification, like “[illegible]” [illegible] throughout the memoir, we regard as neither necessary nor correct.

"equatorial," bearing; the intermediate bearings, which seem to have wide ranges, being termed "E. and W. meridionals," and "N. and S. equatorials." The meridional joints appear to be the most frequent and important. The cause of the jointing is not known: little is allowed to contraction and tension; and the less definite agencies of chemistry, electricity, and magnetism are referred to as probably concerned in its production.

It is also implied (p. 642) that the known secular variation of the magnetic meridian may have existed in very early times, and that "the magnetic polar currents," thus changing their direction, may have produced more or less divergent meridional jointings in course of ages. The author is "not acquainted with *true* jointing in rocks of later periods than the Jurassic in the British Isles"; but accepts the divisional structure of the Gypsum at Montmartre, and of the Nagelfluhe of the Rhigi, as probably Tertiary jointing.

The partial occurrence of such vertical jointing in one set of beds, over- and under-lain by jointed strata, is not only pointed out as a natural phenomenon, but the fact of such a set of joints having been laterally shifted into an oblique position (like a set of sloping books between two parallel shelves) by lateral thrusts, and here termed "dislocated jointing," is clearly expounded as a real cause of what is sometimes regarded as a local cleavage limited to one stratum or stratal series. It is shown also that jointings may really have determined the direction of dislocations, although the uppermost (latest and visible) set of joints may not coincide with the faults; for the lower strata may be cut up by older, deep-seated, and more widely pervading joints, giving direction to the main movements (p. 638).

"We have had," says the author, "examples before us of jointing both unlimited (as in the papery variety), and intermittent. Mineral cleavage I hold to be a superinduced divisional structure, its planes having no relation to incrementation or depositional growth: so it is also with jointing" (p. 640). He admits, however, that slaty cleavage in some rocks may be the result of pressure, rearranging and parallelizing the constituent particles and contained cavities, to produce planes of weakness; but unless the cleavage be practically unlimited or papery,—that is, if it be intermittent with intervals of even less than an inch, he prefers to regard the divisional planes as having been due to the jointing, whether in original vertical position, or modified by disturbance of the stratal mass, with or without lateral pressure. The welding together of joint faces is mentioned as a frequent condition, accounting for what is sometimes described as imperfect cleavage; and what has been treated of by others as secondary cleavage, Prof. King thinks may be also accounted for by modifications of joint-structure under pressure. The difficulty of explaining the discrepancy between the strike of bedding and the strike of cleavage in several known cases is met by the supposition of the lateral crush having been subsequent and oblique to one or more sets of original jointings. Thus, after stating that the *mechanical* theory of cleavage, as advanced by Sharpe, determined by Sorby, and further elucidated by Tyndall and Haughton, necessitates a strictly coincident strike of beds and cleavage,—and after pointing out that in North Devon, Charnwood Forest, the Lake District, Ireland, and elsewhere, differences have been found to exist between the two strikes, Dr. King remarks: "The hypothesis proposed by myself does not limit the action in force to the direction just stated [*perpendicularly* to the resultant planes]: it admits of the force being applied in various directions *against* pre-existing divisional planes: therefore, cases answering to those noticed in the last paragraph do not stand out as antagonistic to it, but as coming within the category of its resultant phenomena. Obviously a force acting in a line deviating to some extent from perpendicularity to joint-planes will bring them into proximity, and weld cognate planes together; though, perhaps, not so effectively as if it had been exerted perpendicularly to them. Moreover, as noticed at p. 638 [limestone near Cork, with complex jointings], jointings of both sets forming the meridional system, one striking east of north, and the other west of north, may occur separately in a great thickness of superimposed rocks, representing two different geological periods—say Devonian and Silurian; therefore pressure exerted uniformly and simultaneously throughout the mass, while acting perpendicularly to the strike of the east-of-north joint-planes in the Silurian rocks, would also be acting obliquely to the strike of the west-of-north jointings in the Devonians: yet it may be consistently held that in both instances slaty cleavage, though necessarily of two discordant strikes, could result from one and the same movement. It appears to me that the above points not only elucidate cases of non-coincidence between the strikes of cleavage and bedding, but they afford a fair and full explanation as to why it is that 'cleavage is symmetrically related to axes of movement of the strata' [Phillips]. So much cannot be said of the purely mechanical hypothesis." (pages 651–2.)

The author states his view of the nature of jointing as follows: "Fully believing that jointing is in the main a physical phenomenon, the particular hypothesis which most strongly suggests itself to my mind, to account for it, is, that it is the product of divisional forces akin to those which give rise to mineral cleavage. The difference between the two phenomena arises, perhaps, from the forces, in the case of jointing, being subordinated to terrestrial magnetism—to laws pervading the crust of the earth; while those productive of mineral cleavage are obedient to crystalline polarity—to laws limited to specific mineral substances or solids. Or, to disarm adverse criticism, usually evoked when anything is ascribed to the mysterious agents that have been introduced (though I wish it to be understood that the circumstances indicate what my leaning is), it may be safer, expressing myself as I did in 1857, to regard both divisional structures as the result of different manifestations of one and the same force." (p. 632.)

The "electro-chemical agents" recognized by the late Evan Hopkins as always silently at work "dissolving, recomposing, and *cleaving*" *both the* deep-seated and the superficial strata of the earth's crust, producing what he termed a "primary structure," and "showing the effect of a polar crystallizing force" (Quart. Journ. Geol. Soc. vol. vi. p. 364), were certainly analogous to, if not identical with Dr. King's world-wide magnetic action producing meridional and other joints. Mr. Evan Hopkins' hypothesis of "cleavage-planes," however, was associated with many untenable views; and certainly did not tend to elucidate the geological structure of either South America or South Australia, to which he applied it. On the contrary, the folded and crushed strata, cleaved by lateral pressure, and showing their obscured bedding-planes only to the instructed geologist, were unravelled on the *mechanical* hypothesis of cleavage alone. So in other countries also; and if this theory be sufficient for such great results, why should we ask for the intervention of an additional divisional structure, of universal range and of enigmatical origin? Dr. King's reply would probably be—at least to account for the above-mentioned cases of imperfect, secondary, and intercalated cleavage-sets, and for some discrepancies in the strike of bedding and cleavage. Good! Jointing is not an uncommon phenomenon, and it must have often been modified by pressure; and hence the explanation, now offered by our author, of some or all of these peculiar stratal conditions. But, as the jointings or other divisional structures, without pressure, will not explain the squeezed, contorted, or elongated conditions of fossils, the parallelized arrangement of particles, and the crumpling of seams, in cleaved rocks, the *mechanical* theory must be accepted, we believe, in most cases, over vast areas of the earth's crust. T. R. J.

II.—ON A NEW METHOD OF DETERMINING THE FELSPARS CONTAINED IN ROCKS. By DR. J. SZABÓ, Professor of Mineralogy and Geology in the University of Buda-Pesth, Hungary; Corr. Memb. Geol. Soc. With 11 Woodcuts and 5 Coloured Plates, pp. 88. (German edition, 1876.)

THIS method is based on those flame-reactions, for the first description of which science is indebted to Bunsen's classical papers, entitled "Löthrohrversuche," and "Flammenreactionen," published in Poggendorf's *Annalen* in the years 1859 and 1866.

The author of the present Memoir has found it necessary to establish a more precise means for determining the fusibility of the non-metallic minerals in general, and especially of the felspars; and he finds that at the same time all the other characters necessary for the exact determination of the species of felspar can also be observed in the flame.

The whole method is exhibited in a series of tables, in which the degrees of fusibility, the peculiar characteristics of the fused products, and the soda and potash reactions of the different species and varieties of the felspar family are very clearly exhibited.

In carrying out this method for determining the species of a felspar, a fragment of the size of a grain of mustard-seed is held in a loop of platinum wire and subjected to the three following experiments. 1.

It is held in the flame of a Bunsen lamp at a height of 5 millimetres from the base for the space of one minute, and its fusibility noted, its soda reaction being observed directly at the same time, and its potash-reaction through cobalt-blue glass or a solution of indigo. 2. The second experiment is in every respect similar to the first, except in the circumstance of the chimney being placed over the Bunsen lamp, and the assay held at the point of fusion (Schmelzraum) of the flame. 3. In the third experiment the assay is first dipped in distilled water, then in powdered gypsum, and lastly placed at the same point of the flame as in the second experiment.

As the lime cannot be directly determined in the presence of soda and potash, the author infers the quantity of this ingredient from the degree of fusibility and the characters of the fused product of the assay. By digesting the assay in hydrochloric acid, however, for twenty-four hours, the lime when present passes into solution, while the alkalies remain almost wholly undissolved. The author bases on this property of the felspars a fourth experiment for confirming the results of the other three.

The success of this method is of course largely dependent on careful manipulation, the details of which are given with great minuteness in the Memoir. Proofs of the accuracy of the results obtained by it are given in a series of comparisons of the numbers yielded by it with those afforded by the ordinary methods of analysis as applied by well-known chemists to some of the best-known species and varieties of felspar. J. W. J.

III.—ON THE CAUSES OF GLACIAL EPOCHS. [EIN BEITRAG ZUR FRAGE UEBER DIE URSACHE DER EISZEITEN.] By Dr. G. PILAR. (Agram, 1876.)

FROM a study of the phenomena presented by the whole Alpine system, and from the observations of Favre in the Caucasus, and our own geologists in Wales and Scotland, the author concludes that we have indubitable evidence of a former general lowering of the temperature, and a great extension of the glacial systems throughout Europe; and although no moraines or other indications of ice-action have been observed in the Altai Mountains, he considers this is merely due to the moisture from the Indian Ocean having been intercepted by the higher ranges of the Himalayas.

The author further adduces the occurrence of huge erratic blocks scattered over Patagonia and the deep fiords of the South-west Coast of South America, and also the physical features of New Zealand, as proofs of the former extension of cold in both hemispheres.

Dr. Pilar also alludes to the former extension through France, Belgium and England of a subarctic fauna and flora in prehistoric times, as evidenced by the remains of the Marmot, Reindeer and other subarctic animals in the caves of these countries.

The author cites the abandonment in the fifteenth century of the earlier Danish settlements in Greenland (founded in the tenth century), also the cessation of the cultivation of rye in Iceland, and e destruction of all the larger trees in that island, together with the osing of many historically well-known passes in the Alps, as idence of recent modifications in the climate, together with various eteorological and botanical observations tending to prove that oscil-tions more or less extensive in the climate of Europe have taken ace in comparatively modern times. Dr. Pilar quotes the earlier servations of Charpentier, in which he suggests, as the probable planation of the former greater extension of the glaciers of the lps, that in the Quaternary period they stood at a far greater eleva-n than at present, thus affording a greater gathering-ground for the vé, and that they have subsequently been lowered by subaerial nudation, the detritus forming the great deltas and alluvial valleys the Rhine, the Rhone, and the Danube, etc.

The author further gives a résumé of the views of Escher von der nth, Dove, Albert Mousson, Sir John Herschel, Sir W. Thomson, yell, etc.

Dr. Pilar concludes that any theory which proposes to account for ch phenomena by local variation of climate will not avail, and at only cosmical causes can have produced them. He cites the inions of Godwin-Austen, Ramsay and others, as to the former idences of glacial action in the New Red and Permian formations; also gives Adhemar's views, formed on Humboldt's observations the alternation of cycles of cold in the northern and southern hemi-heres caused by the greater or lesser eccentricity of the earth's orbit, worthy of consideration. But he concludes that Mr. Croll's theory that which most fully meets the requirements of the case. A rival eory to that of Mr. Croll has been promulgated in Germany by r. H. Schmick, which seems to resemble that of Col. Drayson, ioted by Mr. Belt.[1]

Dr. Schmick believes that the attraction of the sun, alternately ercised on either hemisphere to a greater or less degree, would use alternations in the volume of the oceans of the globe in the two mispheres, resulting in periodic floods and glacial epochs.

One point of interest mentioned by Dr. Pilar is the greater force the south-west trade-winds, which carry a greater amount of pour to the Antarctic Continent than the Arctic Sea, thus causing eater relative condensation.

The chief aim of Dr. Pilar's pamphlet seems to be, first, to give a sumé of the various views of writers on climatic variations in the mperature of the globe; second, to combat the views of Dr. Schmick; d, lastly, to cause those of Mr. Croll to be more generally known the Continent.

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[1] See "An Examination of the Theories that have been proposed to account for e Climate of the Glacial Period," by Thos. Belt, F.G.S., Quart. Journ. Science, 74, No. xliv. See also H. Woodward's Presidential Address to the Geologists' sociation, Nov. 1874. And Anniversary Address by Mr. John Evans, F.R.S., esident Geol. Soc., London, 18th Feb., 1876.

REVIEWS.

◆

GEOLOGICAL SURVEY OF ENGLAND AND WALES.

I.—THE GEOLOGY OF THE WEALD (PARTS OF THE COUNTIES OF KENT, SURREY, SUSSEX, AND HANTS). BY WILLIAM TOPLEY. (In part from the Notes and MSS. of H. W. BRISTOW, W. T. AVELINE, F. DREW, C. GOULD, and Dr. C. LE NEVE FOSTER. Lists of Fossils revised by R. ETHERIDGE.) pp. 503.

II.—THE GEOLOGY OF RUTLAND AND THE PARTS OF LINCOLN, LEICESTER, NORTHAMPTON, HUNTINGDON, AND CAMBRIDGE, INCLUDED IN SHEET 64 OF THE ONE-INCH MAP OF THE GEOLOGICAL SURVEY: WITH AN INTRODUCTORY ESSAY ON THE CLASSIFICATION AND CORRELATION OF THE JURASSIC ROCKS OF THE MIDLAND DISTRICT OF ENGLAND. BY JOHN W. JUDD. (Appendix, with Tables of Fossils, by R. ETHERIDGE.) pp. 320.

WITH the advance of Geology in the British Islands the progress of our Geological Survey is intimately connected; and the numerous publications of Maps, Sections, and Memoirs show how well its original object has been carried out, of arranging, in a form easily accessible to the public, a complete body of information respecting the geological structure of the British Islands, and the disposition and extent of their mineral wealth.

The most original work done by the officers engaged upon the Survey is naturally in the mapping of the exposed surfaces of strata on the Ordnance Survey Sheets, and the illustration of the structure of the country by the publication of horizontal sections on a true scale. The majority of the important cliff-, quarry-, and pit-sections have been studied and described by other geologists, who have also contributed most largely to our knowledge of the palæontological history of the rocks. For while the geological surveyor, in carrying on his work, examines most of the open sections but once perhaps, and is continually entering fresh ground; others studying the geology of a country may return again and again to the same tracts to examine the local details and collect the fossils. And sections open at one time may be closed at another.

The illustration and description of the several tracts of country examined during the course of the Geological Survey cannot therefore be regarded as complete, except the material be gathered from all sources, and in the memoirs there is displayed a proper zeal to do justice to all who have previously studied the districts and published the results of their researches. As the number of observers is constantly increasing, so the memoirs recently issued contain more frequent reference to the observations of others, and are greatly improved by exhaustive lists of all works relating to the country described.

The progress of our English Geological Survey has during the past year been marked by the publication of two important memoirs —the Geology of the Weald, prepared by Mr. Topley; and that of Rutland, by Mr. Judd. Although we have placed these two works together for notice, we must yet treat them in a measure separately, as they deal with distinct areas and strata. While, however, the district described by Mr. Topley has ever been a favourite field for geologists, that into which Mr. Judd carried his observations had been studied but very little previously, and he consequently has had the benefit of recording more new facts, and of establishing the relations of beds concerning which many erroneous opinions had been previously entertained.

I.—A now distinguished Professor of Geology once described the structure of the Wealden area in the following pithy sentences:—"Plutonic action has been very rampant throughout the Wealden area, tossing rocks up and throwing them down, and twisting them about in almost every conceivable manner. A few coloured sheets of paper torn to pieces and then crumpled up and squeezed into a solid mass, will give an adequate idea of their condition before they were brought under atmospheric influences. If we cut valleys in miniature out of the mass of paper, the coloured fragments exposed in their sides will represent most accurately the disconnected surfaces of the rocks, laid bare by rain, frost and the erosive action of the streams." Such a chaotic mass of strata might be considered to represent the structure of the Wealden area by one who, without any previous experience, attempted to unravel the geological structure of some of the many little complicated and faulted tracts that are to be met with in this district; but such is not the idea to be gained from a study of Mr. Topley's very lucid account of the strata.

The Hastings Beds especially are made up of a series of more or less indurated sands and clays, many of the members of which are of a local or impersistent nature; and it is by no means easy, when, as is frequently the case, numerous faults occur, to determine the precise horizon of any bed of clay or sand. Nothing but the systematic mapping of these beds could determine their position; and how well this has been done can be seen from a careful study of the Geological Survey maps of the district. As an instance, the Tilgate beds of Dr. Mantell have been shown to comprise beds on several different horizons. The Lower Greensand exhibits many local variations in thickness, and in the character of the subdivisions that can be made in it.

Both Wealden Beds and Lower Greensand have been subdivided by Mr. F. Drew, and his divisions have been established in the Wealden district.

This area is taken to include all the beds that are enclosed by the Chalk escarpments of the North and South Downs, and the ranges that unite them west of Farnham, Alton, and Petersfield.

The strata described are therefore the Upper Greensand, Gault, Lower Greensand or Upper Neocomian, Wealden Beds, and the Superficial Deposits. But this statement gives but a bare idea of the scope of the work. The many subdivisions of these strata are described in detail; the gravels are treated in their relations to the different streams and rivers; while the Alluvium, Submarine Forests, Blown Sand and Shingle are separately noticed. Physical Geology has received much attention—the structure of the country, its scenery and *agricultural characters being* described.

The denudation of the Weald is ably treated of, and the author, with the benefit of matured reflection, has been able to confirm the theory put forward ten years ago by Dr. Foster and himself. This theory, advocated also by Prof. Ramsay and others, is that of long-continued subaërial action on an ancient "plain of marine denudation."

The origin of the Wealden Beds is discussed, and the evidence would seem to show that they were fluviatile accumulations deposited in a lake. Lastly, Economic Geology, Ironworks, Coal, Springs and Water Supply, Building Stones, Roads and Road Material, Limestones, Manures, and Clays, and the Geological Distribution of Population and Disease, receive a considerable amount of attention.

Lists of Fossils, revised by Mr. Etheridge, are given in an Appendix; which also contains an exhaustive list of books, papers, etc., relating to the Geology of the Wealden area, altogether numbering 564.

The work is well illustrated with maps and sections.

II.—Mr. Judd's Memoir is devoted to a description of the Liassic, Lower and Middle Oolitic rocks, from the Lower Lias to the Oxford Clay inclusive, with notes on the superficial gravels and recent alluvial, estuarine, and marine deposits.

His Introductory Essay, on the classification and correlation of the Jurassic rocks of the Midland District of England with those of other districts, will prove of the highest interest to all students of Geology, for it contains the result of much original thought.

The variations in lithological character, and in fossils, of the several divisions of the Oolitic series, are well illustrated and described by Mr. Judd. The great limestones are of but local development, as is the case with the limestones of the Palæozoic series, and when absent their partial or perhaps total replacement by strata of varying lithological character renders exact correlation a matter of some difficulty. It becomes necessary to adopt different classifications in different tracts of country, which are essentially based on lithological characters. Thus the Northampton Sand in North and East Oxfordshire and South Northamptonshire fills up the interval between the Upper Lias Clay and the Great Oolite Limestone. Palæontologically the upper part of the Sand is considered as representing the lower zone of the Great Oolite, while the lower portion of the Sand is considered as the equivalent of the lower beds of the Inferior Oolite.

The Midford Sand of the south-west of England would seem to be partly homotaxeous with the Northampton Sand. In the Vale of Moreton, Mr. Judd thinks it possible that the Midford Sand which underlies the Inferior Oolite series either thins out altogether in the northern spurs and outliers of the Cotteswolds, or its attenuated representative is lost in the Northampton Sand.

He has been enabled, in places, to separate portions of the Northampton Sand of Great Oolite age from that of Inferior Oolite age; the upper beds consist of sandy clays, and present evidences of an estuarine origin; hence they have been termed the Upper Estuarine Series.

Evidences of unconformity, too, have been traced in the Midland district, proving local upheaval and denudation, which probably occurred when the Fuller's Earth and upper portion of the Inferior Oolite were being deposited in the West of England.

In the district more particularly described by Mr. Judd, the Northampton Sand, with the Lower Estuarine Series, are often seen lying upon an eroded surface of the Upper Lias Clay.

The determination of the age of the Lincolnshire Limestone, first surmised by the Rev. P. B. Brodie and Dr. Lycett in 1850, was not adopted, because some confusion was made with the so-called "slates," which, as Mr. Judd points out, occur at several horizons in the Oolitic series. In 1866, he was led to regard the Lincolnshire Limestone as of the age of the Inferior Oolite, and while engaged upon the Geological Survey (1867–70) this view was confirmed on both stratigraphical and palæontological grounds. And in this, additional corroboration has been furnished by the researches of Mr. Samuel Sharp and Mr. Beesley. The variations in the attempted divisional line between Middle and Lower Lias, based on palæontological evidence, are discussed: such evidence proves that lines at different horizons would be taken in different places; and as the clayey beds of the Lower Lias merge often imperceptibly into the sands and clays of the Middle Lias, it is seldom possible to draw a definite line in the field.

Mr. Judd's remarks on zones—strata marked by a *general assemblage* of forms—are interesting: but zones can only be appreciated and identified by long-continued palæontological research. There is much perplexity in them. "It must be remembered too," says Mr. Judd, "that every zone may present several *facies;* the petrological and palæontological features which characterize these being dependent on the conditions under which the strata were deposited at different points. The faunas of deposits belonging to two facies of the *same* zone may differ from one another more widely than those of beds of corresponding facies of *different* zones."

The origin of the Northampton Sand forms an interesting and important essay in itself, and was in 1869 communicated to the Geological Society, and postponed (owing to official regulations) for publication in this Survey Memoir.

The descriptions of the Liassic and Oolitic strata are accompanied by copious lists of fossils; and an Appendix, prepared by Mr. Etheridge, shows the distribution of the species.

In the chapter on Post-Tertiary deposits are notes on Pre-Glacial deposits; Glacial deposits, including notices of large transported masses of Inferior Oolite and Marlstone; Post-Glacial deposits, such as Cave deposits, Valley gravels, Estuarine gravels, Marine gravels, and Alluvium.

Faults, Denudation and Scenery, Springs, Swallow Holes, etc., likewise receive due treatment. The list of works relating to the district, furnished by Mr. Whitaker, includes 110 different papers and books.

We cannot close this notice without a few words in acknowledgment of Mr. Judd's disinterested devotion to Geology; for after resigning his appointment on the Geological Survey, he gave up his own time to the preparation of this Official Memoir.

The work of the Survey, rendered more detailed every year by the advance of the science, would seem no light work as fresh districts are entered, and the literature of the subject comes to be studied. And when Mr. Topley tells us that great part of his Memoir was prepared amongst the Northumbrian Moors, we can understand that literary work involving bibliographical research was carried on at considerable disadvantage. To him and to Mr. Judd great credit is due for the admirable manner in which all the facts connected with the respective districts they have described are placed before their readers. We do not think that the task of either could have been performed more satisfactorily, and we can only regret that the price of 28*s*. is likely to debar many poor geologists from purchasing Mr. Topley's Memoir, while the price of 12*s*. 6*d*. for Mr. Judd's book seems disproportionately low. The volumes, moreover, neither correspond in size nor in the "lettering," but these are mysteries which we cannot pretend to fathom; they are among the hidden things of Her Majesty's Stationery Office, and past finding out!

REPORTS AND PROCEEDINGS.

Geological Society of London.—I.—March 8, 1876.—Professor P. Martin Duncan, M.B., F.R.S., President, in the Chair.

The following communications were read:—

1. "On the Influence of various substances in accelerating the Precipitation of Clay suspended in Water." By Wm. Ramsay, Esq., Principal Assistant in Glasgow University Laboratory. Communicated by Prof. Ramsay, F.R.S., V.P.G.S.

The author, referring to the fact that clay when suspended in water in excessively minute particles settles more rapidly when the water contains salts in solution, noticed the opinions expressed by previous writers on the subject, and gave the results of experiments made by him, from which it would appear that the rapidity of precipitation is proportionate to the amount of heat absorbed by the salts in process of solution. By another series of experiments he found that the fluidity of the respective solutions had apparently no influence on the rapidity of deposition of the clay. He also found that clay is deposited less quickly in acid solutions than in solutions of salts, and more rapidly in a solution of caustic soda than in one of caustic potash. In solutions of common salt of different strengths he found that clay settled in the inverse order of their specific gravities. From all these results the author is inclined to attribute the varying rapidity of the settling of clay suspended in saline solutions to the varying absorption of heat by the solutions. When water containing suspended clay was heated, the rapidity of the settling of the clay was proportionate to the heat of the water. The author suggests that the increased rapidity of settlement may be due to the greater amplitude of vibration of the molecules of water when heated; the vibrations being performed in equal times, particles descending at right angles to the plane of vibration will experience less resistance from the molecules of water.

A note by Prof. Ramsay, briefly indicating some of the geological bearings of these results, was appended to the paper.

2. "On some Fossiliferous Cambrian Shales near Carnavon." By J. E. Marr, Esq. Communicated by Prof. T. M'Kenny Hughes, F.G.S. With an Appendix by Henry Hicks, Esq., F.G.S.

The shales described by the author extend from about three miles S.W. of Carnarvon to Bangor, running nearly parallel to the Menai Straits. They are faulted against Lower Cambrian to the east, and disappear against a dyke on the west. The shales vary from greyish black to bluish black in colour, and are generally sandy and micaceous, but in places chiefly clayey. Fossils were obtained from three places on the banks of the Seiont, namely, near Point Seoint (where the beds are concretionary in structure), along the old tramway from Carnarvon to Wanttle, and near Peblig Bridge. The first-named locality is richest in fossils; and here there is a greenstone dyke, parallel to the bedding of the rock, and altering the shales for a distance of about four yards from the edge of the dyke. The fossils seem to indicate that the deposit belongs to the upper part of the Arenig group.

Appendix.—Mr. Hicks pointed out that the fauna clearly showed that these beds belong to the Arenig group, many of the species being identical with those found in the upper part of that group at St. David's, Shelve, and in Cumberland. The new species found by Mr. Marr are a *Caryocaris* (*C. Marrii*) and an *Æglina* (*A. Hughesii*). The other fossils were *Didymograptus indentus*, *D. bifidus*, *D. Murchisoni*, and the var. *furcillatus*. Species of *Barrandea*, *Trinucleus*, *Lingula*, *Obolella*, *Discina*, etc., and *Orthoceras caeresiense*. The rock in its general character is extremely like that at the same horizon in the succession at St. David's, Shelve, and in Cumberland, and indicates, therefore, the prevalence of similar physical conditions when deposited. The rock is such as would be formed over an even sea-bottom at some considerable distance from land and in moderate deep water. Mr. Hicks looked upon this discovery as of considerable importance, since it clearly proved the position of beds hitherto imperfectly known, and moreover shows that similar conditions prevailed over extensive areas at the time these beds were deposited. It also furnished further evidence in support of Mr. Hicks's opinion that no break occurs anywhere in the Welsh area between the Cambrian and Lower Silurian rocks.

3. "On the Occurrence of the Rhætic Beds near Leicester." By W. J. Harrison, Esq., F.G.S., Curator of the Town Museum, Leicester.

The sections described by the author are shown in brick-pits in the Spinney Hills, forming the eastern boundary of the town of Leicester, and in the Crown Hill on the eastern side of a valley excavated by the Willow Brook. In the latter locality they are capped by Lower Lias. They have a slight dip to the south-east.

The brick-pits show a thickness of about 30 feet of Rhætic beds above the Triassic red marl, to which their stratification is parallel. The lowest bed is a light-coloured sandy marl about 17 feet thick, traversed by three or four courses of harder, whiter stone, and containing crystals of selenite, pseudomorphs of salt, and numerous small fish-scales. A single insect wing was obtained from it. This bed extends across the valley of the Willow Brook, and forms the base of Crown Hill. Above it comes the Bone-bed, from 2 to 3 inches thick, containing numerous small teeth, bones, and scales of fishes and Saurians, including large vertebræ of *Ichthyosaurus*, ribs probably of *Plesiosaurus*, and some bones of Labyrinthodont character. Two species of *Axinus* also occur. The Bone-bed is followed by about 2½ feet of coarse black shales, overlain by a very thin band of hard reddish sandstone, with casts of *Axinus*, and this by about 2 feet of finely laminated black shales containing *Cardium rhæticum*, *Avicula contorta*, and a Starfish (*Ophiolepis Damesii*). Above these come about 5 feet of shales with sandy partings, the lower foot rather dark and containing *Avicula contorta*, *Cardium rhæticum*, *Ostrea liassica*, and a new *Pholidophorus;* the remainder light-coloured, but with the same shells. The topmost bed in the section is a band of nodular limestone 6 inches thick. The same sequence is observed in Crown Hill. There are indications of the existence of a second nodular limestone and of beds of light-coloured clay and sand, but obscured by drift, in which, however, blocks of limestone occur with *Monotis decussata* and *Anoplophora musculoides.* The author indicates other localities where traces of the Rhætic beds are to be seen, and states that wherever the true junction of the Trias and Lias is exposed, the Rhætics appear to be invariably present. The paper also included some particulars with regard to borings in the Trias near Leicester.

4. "Hæmatite in the Silurians." By J. D. Kendall, Esq., F.G.S. The author referred to a former paper in which he showed that the direction of the hæmatite deposits in the Carboniferous Limestone of Cumberland and Lancashire is parallel to that of the meridional divisional planes, or nearly north and south; while the deposits in the Silurians are in two directions, some parallel to one set of divisional planes and some to the other. In the present paper he describes a deposit of hæmatite at Water Blean, in the parish of Millom in Cumberland, in Coniston Limestone, which appears to be altogether unlike those referred to in his former paper. The Silurians here are all conformable, with a strike about 65° N.E. and S.W. and a dip of about 80° to N.W., but their order is inverted. The hæmatite occurs in the Coniston Limestone in the form of short veins, varying in width from a few inches to 9 feet, running in the direction of the strike, and having the same dip as the limestone, their deposition having taken place along the bed-joints of the rock. The author accounts for this difference in the deposits by the fact that in the Coniston Limestone at Water Blean the bed-joints are much more persistent than the divisional planes, which are very irregular, and not at all so strong and open as the bed-joints.

II.—March 22, 1876.—Professor P. Martin Duncan, M.B., F.R.S., President, in the Chair.

1. "On the Triassic Strata which are exposed in the Cliff Sections near Sidmouth, and a Note on the Occurrence of an Ossiferous Zone containing Bones of a *Labyrinthodon*." By H. J. Johnston Lavis, Esq., F.G.S.

The author described the base of the cliffs east of Sidmouth as composed of the Marl which is the uppermost subdivision of the Trias in South Devon, capped in Littlecomb Hill and Dunscomb Hill by Greensand and Chalk, and in Salcombe Hill by Greensand alone. In the valley of the Sid it is largely exposed at the surface. Close to the mouth of the Sid the Upper Sandstone crops out beneath the marl, forming a cliff overhanging the river. To the west of Sidmouth there is a low projecting cliff, the Chit rock, formed also of the Upper Sandstone, and at the western end of this is a fault which has given the Chit rock an upthrow of at least 40 and perhaps of 80 feet, since it has no marl capping it, and in its lithological character it resembles the middle part of the Upper Sandstone. To this point the dip is to the east; but westward of the fault the dip is at first to the west for about half a mile, when the sandstone reappears with an easterly dip, having formed a synclinal curve. It is overlain by Marl and Greensand in Peake and High Peake Hills, which are capped with Chalk gravels. West of High Peake Hill the Sandstone forms the whole cliff. The author described the general characters presented by the Triassic beds in the section under notice, and mentioned the occurrence at about ten feet from the top of the Sandstone of a peculiar series of beds, composed of coarse sandstone, containing scattered nodules of marl from the size of a pea to that of a hen's egg, together with numerous fragments of bone, some of which, belonging to a species of *Labyrinthodon*, would be described by Prof. Seeley. The author mentioned that he had received from the Rev. S. H. Cooke some fragments of bone obtained by him twenty years ago from this same "Ossiferous Zone." Mr. Whitaker's specimen of *Hyperodapedon* was also obtained from the Upper Sandstone.

2. "On the Posterior Portion of a Lower Jaw of *Labyrinthodon* (*L. Lavisi*) from the Trias of Sidmouth." By Harry Govier Seeley, Esq., F.L.S., F.G.S., Professor of Physical Geography in Bedford College, London.

After referring to the doubtful position of the Labyrinthodontia in the system, and expressing his doubts as to the occurrence of the genus *Mastodonsaurus* in Britain, the author proceeded to describe in detail the posterior part of the right ramus of the lower jaw of a Labyrinthodont, obtained by Mr. Lavis from the Ossiferous Zone of the Trias near Sidmouth, the position of which was described by that gentleman in the preceding paper. The specimen, which is 13 inches long, and perfectly free from matrix, shows that the lower jaw in Labyrinthodonts not only contains articular, angular, and dentary elements, as hitherto supposed, but also separate splenial and surangular elements, and probably a distinct coronoid bone.

These bones were described in detail; and the author remarked that, although they are somewhat reptilian in aspect and arrangement, they are not very suggestive as to the affinities of *Labyrinthodon.* They surround a central hollow space, which no doubt received the primitive cartilage round which the bones were ossified; and the persistence of this character would seem to be a link rather with the lower than with the higher Vertebrata. The jaw differs from the Batrachian mandible in possessing well-developed angular and surangular elements; and some reptiles, such as Crocodiles and the marine Chelonia, present analogies in the perforations, the structure of the jaw, and the sculpture of the bones. In size the specimen is almost identical with that figured by Mr. Miall as belonging to *Labyrinthodon pachygnathus,* but the depth and outlines of the postarticular part of the jaw, and differences in the sculpture of the lateral subarticular ornament, furnish distinctive characters which lead the author to describe the present species as representing a new species, which he names, in honour of its discoverer, *Labyrinthodon Lavisi.* The author briefly noticed several other bones and fragments obtained by Mr. Lavis in the same locality, some of which probably belonged to the same skeleton.

3. "On the Discovery of *Melonites* in Britain." By Walter Keeping, Esq. Communicated by Prof. T. M'Kenny Hughes, F.G.S.

The author described a specimen from the Carboniferous Limestone of Derbyshire in the Museum of the Geological Survey, which displays numerous plates belonging to the test of a large Echinoid, considered by him to be a new species of the genus *Melonites,* hitherto regarded as peculiar to America. The author proposed to call this species *Melonites Etheridgii,* and he described it as possessing a more or less spheroidal test, about seven inches in diameter, composed of very thick plates, arranged in five ambulacral and five interambulacral areas, all the plates being ornamented with minute tubercles for the support of spines. The interambulacral areas were probably about twice as broad as the ambulacral, and composed (at the equator) of about nine ranges of plates, the marginal ones pentagonal, the rest hexagonal, articulating with each other by faces varying from a right angle to one of 30°. The ambulacral areas were broad, each formed of two convex ribs separated by a meridional depression running from mouth to anus, and each rib (half-area) composed of six or seven ranges of irregular plates, each perforated by a pair of simple pores. The tubercles are minute, imperforate, without boss, and of two orders, the larger surrounded by a smooth areola, bounded by an elevated ring. The spines are small, tapering, coarsely sulcate, with a prominent collar round the articular end. A second specimen exists in the British Museum. The species differs strikingly from the North American *Melonites multiporus* in the characters of the ambulacral areas, which have 12–14 ranges of plates, and are divided by a meridional furrow in the new species, and only eight ranges of plates, with a median ridge formed of plates twice as large as the rest in *M. multiporus.*

4. "*Note on the Phosphates of the Laurentian and Cambrian Rocks of Canada.*" By Principal Dawson, LL.D., F.R.S., F.G.S.

The author described the mode of occurrence of phosphatic deposits in various localities in Canada. Dark phosphatic nodules, containing fragments of *Lingulæ*, abound in the Chazy formation at Allumette Island, Grenville, Hawkesbury, and Lochiel. Similar nodules occur in the Graptolite shales of the Quebec group at Point Levis, and in limestones and conglomerates of the Lower Potsdam at Riviere Ouelle, Kamouraska, and elsewhere on the Lower St. Lawrence; these deposits also contain small phosphatic tubes resembling *Serpulites*. The Acadian or Menevian group near St. John, New Brunswick, contains layers of calcareous sandstone blackened with phosphatic matter, consisting of shells and fragments of *Lingulæ*. The author described the general character of the phosphatic nodules examined by him at Kamouraska, and gave the results of analyses made of others from various localities which furnished from 36·38 to 55·65 per cent. of phosphate of lime. A tube from Riviere Ouelle gave 67·53 per cent. The author accepted Dr. Hunt's view of the coprolitic nature of the nodules, and inclined to extend this interpretation to the tubes. The animals producing the coprolites could not be thought to be vegetable feeders; and he remarked that the animals inhabiting the primordial seas employed phosphate of lime in the formation of their hard parts, as had been shown to be the case with *Lingulæ*, *Conularia*, and the Crustaceans. The shells of the genus *Hyolithes* also contain a considerable portion of phosphate of lime. Hence the carnivorous animals of the Cambrian seas would probably produce phosphatic coprolites.

With regard to the Laurentian apatite deposits, the author stated that they, to a great extent, form beds interstratified with the other members of the series, chiefly in the upper part of the Lower Laurentian above the *Eozoon*-limestones. The mineral often forms compact beds with little foreign matter, sometimes several feet thick, but varying in this respect. Thin layers of apatite sometimes occur in the lines of bedding of the rock. Occasionally disseminated crystals are found throughout thick beds of limestone, and even in beds of magnetite. The veins of apatite are found in irregular fissures; and as they are found principally in the same parts of the seams which contain the beds, the author regarded them as of secondary origin. The Laurentian apatite presents a perfectly crystalline texture, and the containing strata are highly metamorphosed. The author's arguments in favour of its organic origin are derived from the supposed organic origin of the iron-ores of the Laurentian, from the existence of *Eozoon*, from the want of organic structure in the Silurian deposit described by Mr. D. C. Davies, and the presence of associated graphite in both cases, from the character of the Acadian linguliferous sandstone, which might by metamorphism furnish a pyroxenite rock with masses of apatite, like those of the Laurentian series, and from the prevalence of animals with phosphatic crusts in the Primordial age, and the probability that this occurred also in the earlier Laurentian. The position of the phosphatic deposits above the horizon of *Eozoon* is also adduced by the author as adding probability to the existence of organic agencies at the time of their formation.

CORRESPONDENCE.

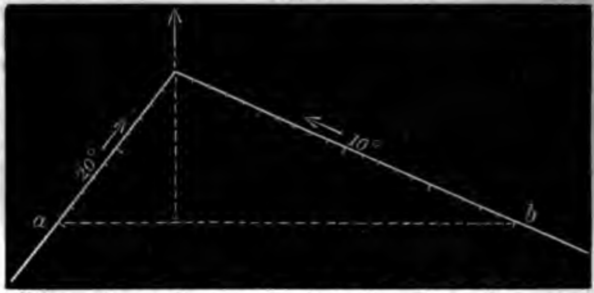
APPARENT AND TRUE DIP.

Sir,—Although the principle involved is always the same, the methods given below for finding the true from the apparent dip are, I believe, new; and in the hope that they may be found by others as serviceable as by myself, I send them for insertion in the Geological Magazine.

To find direction of dip.—When the amount and direction of two lines of apparent dip are known, the direction of the true dip may be found by one of the following rules, *A* or *B*.

Rule A.—When both the observed dips incline from, or towards, the angle enclosed by their lines (Fig. 1), the true dip is at right angles to a line *a b* laid down by the following method.

Fig. 1.

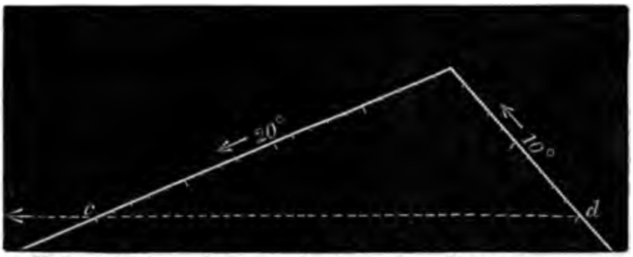


Set off from the angle on each of the two lines of apparent dip, a number of units corresponding to the number of degrees of dip observed along the *other* line, and connect the two points by a line *a b*.

This line, *a b*, coincides with the strike, and is consequently at right angles to the true dip's direction.

Rule B.—When one observed dip inclines from, and the other towards the angle enclosed by their lines (Fig. 2), the true dip follows a line *c d* laid down by the following method.

Fig. 2.

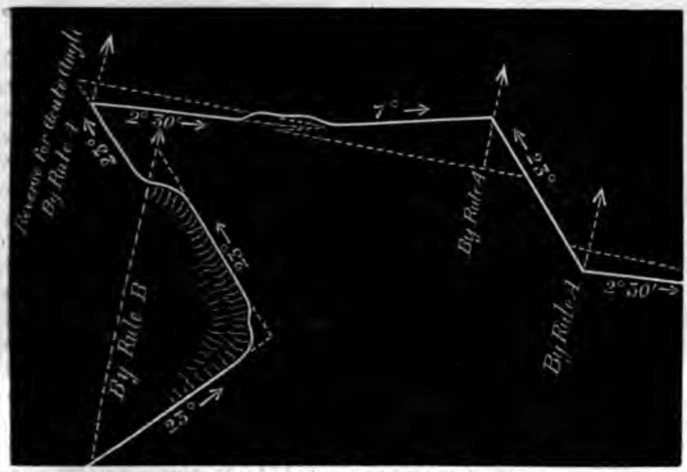


Set off from the angle on each of the two lines of apparent dip, a number of units corresponding to the number of degrees of dip observed along that line, and connect the two points by a line *c d*.

This line coincides with the true dip's direction.

Note.—These rules will not apply unaltered to lines of apparent dip enclosing *acute* angles, which in practice are rarely found. In such cases a horizontal triangle constructed by the *reverse* rule, *i.e.* on the other side of either line of observed dip, will give the result required.

Fig. 3.



The quarry represented in Fig. 3 may be taken as an example of obtaining the true dip by these methods. The operation being repeated under varying conditions with the same result.

H. M. Geological Survey. W. H. Penning.

THICKNESS OF THE OXFORD CLAY.

Sir,—As few of your readers may possibly see my Lecture on the Water Supply to Houses and Towns with especial reference to Oxford, I beg to enclose an extract from it, having reference to a question which is of some geological interest, viz. the thickness of the Oxford clay in this district. The inquiries I had occasion to make respecting the practibility of an artesian well at Oxford led me to doubt previous conclusions. In the following extract from my pamphlet I give the geological grounds on which I arrived at this different result.

"We know generally that the Oolites become thinner in their range eastward, but the Oxford clay has, on the contrary, been thought to become thicker, and it has been generally stated, on the evidence chiefly of the boring made at Wytham[1] in 1829, that at Oxford it is 600 ft. thick, or more.

"I am satisfied however, that there is some error in the construction put on that section, and that the thickness of the Oxford clay here is much less than that estimate. A record of the boring has been preserved, which shows it to have been carried through a succession of clay and rock strata, to the depth of 632 feet. Unfortunately the record was drawn up by coal-miners, who have employed the terms in common use in the coal-fields, and no specimens have been preserved which would have enabled us to correct the deficiencies of description; nevertheless there is sufficient evidence, on independent grounds, to show that the strata, so far from belonging all to the Oxford clay, include probably the whole of the Oolitic series, and part of the Lias.

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[1] Three miles N.N.W. from Oxford.

"My reasons for believing the assignment wrong are these: in the Oxford clay, whether seen in sections at St. Clement's, Oxford, Summertown, or elsewhere, no beds of rock are met with,—nothing but a few seams of septaria, nor have any been found in the outcrop or pits of the lower division of this formation at Kirtlington or North Leigh, or in any well-sections. The 10 ft. of Kelloway rock which lies at the base of the Oxford clay in Wiltshire, has not been recognized in Oxfordshire. The alternation of thick beds of rock, some of them 30 ft. thick, and of a light colour, such as described in the Wytham boring, is entirely unknown in the Oxford clay of any part of England. I should therefore exclude these rock strata, and restrict the Oxford clay at Wytham to the strata numbered 1 to 24 inclusive, the total thickness of which is 273 ft. No. 25, 'a strong blue rock,' 10½ ft. thick, I should refer to the Cornbrash; No. 26 to 32, alternating clays and rock 33 ft. thick, to the Forest Marble; No. 33 to 50, consisting of grey and light coloured rocks, two of them 30 ft. thick, with seams of clay, altogether 131½ ft. thick, to the Great Oolite; No. 51 and 55, together 14½ ft., to the rubbly Inferior Oolite of Fowler; while the thin seam of ironstone and the clays with ironstone, No. 53 to 59, which were penetrated to the depth of 170 ft., may represent the Marlstone and Lower Lias; the Upper Lias, which at Fowler is reduced to a thickness of 5 ft., has here apparently thinned out.

"If we compare the section grouped in this manner with the dimensions and characters of the several Oolitic formations immediately north of Oxford, as described by Prof. Phillips,[1] Prof. Hull,[2] and Mr. Green,[3] they will be found to agree very closely.

Average Thickness of Strata at Charlbury, Woodstock, and Enslow Bridge.

	ft.	
Cornbrash	9	179
Forest Marble	25	
Great Oolite—Upper	60	
„ „ Lower... ...	70	
Inferior Oolite	15	
Upper Lias	8	
Marlstone and Lower Lias	400	

Thickness of the Strata at the Wytham boring.

Beds.	ft.	in.	
No. 25	10	6	190 6
„ 26—32	33	0	
„ 33—50	131	6	
„ 51, 55	14	6	
	wanting ?		
„ 56, 59	170	6[4]	

"A few years later, another boring was made at St. Clement's in search of water. No particulars are preserved. It was 420 ft. deep, and is merely stated to have been through 265 ft. of clay, and 135 ft.

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[1] Geology of Oxford, pp. 139, 297, and 495.

[2] Mem. Geol. Survey, Geol. of Sheet No. 45 S.W., pp. 14, 26, and 30.

[3] Ibid., Geol. of Sheet No. 45, p. 9 et seq.

[4] Described as a uniform bed of clunch (clay) with ironstone.

(should be 155) of rock. These beds have also been assigned to the Oxford clay, but Mr. Stackpole speaks of the rock below a depth of 265 ft. as referable to the Great Oolite; but upon what evidence he does not say. If, however, a nearly horizontal line (the dip of the strata is nearly horizontal) be prolonged, from the level at which we have placed the Oxford clay at Wytham, it will be found to coincide almost exactly with the base of the clay at St. Clement's, and both series would naturally fall into the same category."

I conclude, therefore, that instead of being 600 ft. thick and more, the Oxford clay in the neighbourhood of Oxford does not exceed 320 to 350 ft., and further, there is evidence to believe that the Lower Lias itself thins out at no great distance, and even that the New Red Sandstone is at no great depth beneath Oxford. Besides its geological bearing, this is important in case, at some future period, of any attempt to search for coal in Oxfordshire or Buckinghamshire.

E.—SECTION OF WYTHAM BORING.

(From Phillips's "Geology of Oxford," p. 296.)

"The following is a summary of the results obtained in this remarkable boring, copied from a section presented to the Oxford Museum in 1849, by the Earl of Abingdon. The terms employed by the workmen are used in the coal-fields of Staffordshire for strata somewhat analogous :—

	ft.	in.
1. Loamy ground	12	0
2. Quicksand and water	3	0
3. Blue clunch	68	6
4. Light clunch	1	6
5. Blue clunch	28	6
6. Clunch bines	4	6
7. Blue clunch	29	0
8. Clunch bines	2	0
9. Blue clunch	28	0
10. Brown clunch	3	0
11. Mingled ground	11	6
12. Strong grey rock	1	0
13. Grey clunch	2	0
14. Brown clunch	1	6
15. Mingled ground	17	0
16. Blue clunch bines	6	0
17. Mingled ground	4	0
18. Blue clunch	17	6
19. Mingled ground	9	6
20. Blue clunch	5	0
21. Dark blue rock	3	6
22. Dark parting clunch	0	6
23. Dark blue rock	2	6
24. Dark clunch	11	6
25. Strong blue rock	10	6
26. Dark parting clunch	1	0
27. Strong blue rock	5	6
28. Strong parting clunch	0	6
29. Blue rock	1	6
30. Clunch and clunch bines	6	0
31. Grey rock	18	0
32. Dark parting clunch	0	6
33. Light rock	30	3
34. Light parting clunch bines	0	9
35. Light rock	5	0
36. Very dark parting	2	0
37. Grey rock	1	4
38. Dark parting	0	8
39. Clunch bines	7	6
40. Grey rock	3	0
41. Dark parting	1	6
42. Grey rock	2	6
43. Blue Bines	2	0
44. Mingled ground	3	0
45. Blue rock	9	0
46. Dark ground	1	6
47. Mingled ground	7	6
48. Light rock	16	6
49. Black bat	2	0
50. Rock	35	6
51. Mingled ground	11	6
52 to 55. Mingled ground	3	0
56. Ironstone	0	4
57. 58. } Clunch mixed with ironstone	132	0
59. Dark clunch	2	0

"The boring was carried to the depth of 211 yards, the strata the same as that at 596 feet."—C. WEBB.

"The boring was made in 1829." JOSEPH PRESTWICH.

THE OLDEST FOSSILIFEROUS ROCKS OF NORTHERN EUROPE.

Sir,—I have read the paper by Professor Linnarsson in the last Number of the Geological Magazine with much interest; but I fail to see in it any facts stated which require that I should in any way modify the views there criticized. Indeed, I must claim the evidence brought forward as tending strongly to confirm those views. As this subject will be treated of fully in my paper, which is now being published in the Geol. Mag., I will here only refer to one or two points which Professor Linnarsson seems to have lost sight of in his paper.

1. If the Swedish area was submerged, as suggested by him, at as early a period as the British area, there is no reason why it should not have been depressed to as great a depth. That this could not have been the case, however, is quite clear from the examination of the faunas and the sediments. The average thickness of the sediments in the British area at the close of the Cambrian was at least 15,000 feet, and at the close of the Lower Silurian 30,000 feet. As these are perfectly conformable sediments, it is certain that a depression of over that amount had taken place. The average thickness for the same period in Sweden is scarcely over 1,000 feet; hence if the depression there was equal to that in Britain, the sediments there before the close of the Lower Silurian must have been deposited in a depth of 29,000 feet of water. I do not think Prof. Linnarsson can possibly mean that the Swedish fauna of that period was likely to have inhabited a sea of that depth. The British and Swedish faunas are in many respects alike, and indicate the presence at that time of very similar conditions. And the reef-building corals so plentiful in each area prove conclusively that the depth of water could not have been very great.

2. As to the resemblance between the Harlech and Menevian faunas, it is not greater than what might naturally be expected in groups succeeding one another. The likeness indeed is not greater than between widely separated groups in the Silurian. Moreover, no one will believe that the forms of life in the Menevian had not earlier representatives, and which need not have differed from them very greatly. Indeed, the large size and high state of development of the Trilobites in the Menevian group prove conclusively to my mind that this state could only have been attained through many previous faunas of a similar type. Hence it is but reasonable to suppose that the very earliest Cambrian fauna which could be discovered would not differ greatly from the Menevian, and moreover that these forms of life were probably in existence before a single bed of the European Cambrian rocks had been deposited, or even the waters had encroached on the old pre-Cambrian European Continent.

April, 1876. Henry Hicks.

UNFADING INK.

Sir,—Would you or any of your readers kindly tell me of the most suitable and durable ink for marking Chalk specimens. I have for the last eighteen years marked them with common writing ink; but I now find that in a great number of cases the writing is fast disappearing, and that I must soon re-mark them with something more durable, if I can find it.

Driffield, East Yorkshire, J. R. Mortimer.
April 10th, 1876.

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ORIGINAL ARTICLES.

I.—On the Vertical Range of the Graptolitic Types in Sweden.

By Dr. G. Linnarsson,
Director of the Geological Survey of Sweden.

Of the Swedish Graptolites up to this day but very little seems to be known in foreign countries. They merit, however, more attention than has hitherto been bestowed on them—chiefly perhaps because of the scantiness of the literature. The Graptolitic faunæ of Sweden have many analogies to those of other Silurian districts, and are therefore of great importance for the identification of the strata. An acquaintance with them is also required if one wishes to obtain a somewhat accurate knowledge of the vertical and horizontal range of the various types. A short account of them might therefore possibly have some interest even to an English geologist.

In Sweden it is chiefly at four horizons that the Graptolites are numerous and predominant, but also at many others some single species are found. In general the Graptolitic faunæ in Sweden are more separate and unmingled than in England, certain forms which in England have a wide vertical range being in Sweden restricted to one horizon.

The Cambrian and Silurian deposits of Sweden can be arranged in the following manner, in descending order:—

1. *Encrinurus* Beds.
2. *Leptæna* Limestone.
3. Upper Graptolitic Schists.
4. *Brachiopod* Schists.
5. *Trinucleus* Schists.
6. *Chasmops* Limestone.
7. Middle Graptolitic Schists.
8. *Orthoceras* Limestone.
9. Lower Graptolitic Schists.
10. *Ceratopyge* Limestone.
11. *Dictyonema* Schists.
12. *Olenus* Schists.
13. *Paradoxides* Schists.
14. Fucoid Sandstone.
15. *Eophyton* Sandstone.

The *Sandstones*—which lie unconformably on the fundamental gneiss, and are overlain by the "Primordial Zone," thus agreeing in position with the English "Longmynd Group"—have not yielded any Graptolites, if we except a single, very faint, impression found in the shale accompanying the *Eophyton* Sandstone, which represents a *Dictyonema* or something allied to that genus. I am, however, very uncertain of the true nature of this impression; it is possible that it is not even of organic origin.

In the *Paradoxides* beds, I have myself seen no traces of Graptolites, nor have any been found by other observers.

The oldest Graptolite hitherto described from Sweden is the

Dichograptus tenellus, Linrs. It occurs in the uppermost part of the *Olenus* Schists of Westrogothia, together with *Sphærophthalmus alatus*, Boeck. The rock which has yielded it corresponds with the Upper Dolgelly of Mr. Belt.

The *Dictyonema* Schists, which occur in Ostrogothia and Scania, abound in *Dictyonema flabelliforme*, Eichw., and contain in Scania also a *Dichograptus* in very great number. Almost the only other fossil found in these schists is a Brachiopod resembling the *Obolella Salteri*, Holl, from the Malvern Hills, which does not, however, in England occur together with *Dictyonema*, but in a somewhat lower horizon. The *Dictyonema* Schists of Ostrogothia in all respects agree with the bituminous schists which in the Baltic provinces of Russia overlie the "Ungulite Grit." In certain localities in Scania, *Dictyonema* seems also to occur in the uppermost part of the *Olenus* beds, and there a transition might thus take place between the *Olenus* Schists and the *Dictyonema* Schists, while in Ostrogothia they seem to be sharply defined.

From the *Ceratopyge* limestone not a single Graptolite is known, though it contains intercalated bands of schists. In the overlying Lower Graptolitic Schists they occur, on the contrary, very plentifully. The fauna of these schists is quite analogous to that of the Skiddaw and Quebec groups, but hitherto a far less number of generic types has been found in Sweden than in England and Canada. The most common genera are *Phyllograptus* and *Didymograptus*. The former is the most characteristic, and therefore the Lower Graptolitic Schists might also be termed "*Phyllograptus* Schists." *Didymograptus* is represented by several species, but in some localities is comparatively rare. Besides the above, there are not with certainty known any more genera than *Tetragraptus* and *Dichograptus*. There is also an extremely slender branched form, of which I have not been able to make out the generic characters; but perhaps it belongs to *Pleurograptus*. In one single locality, at Fåjelsang in Scania, I have, together with forms characteristic of the Lower Graptolitic Schists, such as *Phyllograptus* and *Didymograptus hirundo*, found numerous specimens of a *Climacograptus*, a genus which elsewhere in Sweden is found only at higher horizons. The stratigraphical relations of the schists containing this mixed fauna have not yet been made out. In petrographical as well as in palæontological respects they differ from the true and undoubted Lower Graptolitic Schists found at other places in Scania, which, as those of Westrogothia and Jemtland, have yielded no traces of *Diplograpti* or *Climacograpti*. I have guessed that the schists in question might possibly be intercalated in the *Orthoceras* Limestone. In Norway the *Orthoceras* Limestone contains intercalated bands of schists, but of their faunæ nothing is known. Some authors have referred the Skiddaw and Quebec groups to the Primordial Zone. That view must, however, be abandoned, as those groups are evidently equivalent to the Swedish Lower Graptolitic Schists, which repose on a bed—the *Ceratopyge* Limestone—the fauna of which has a decidedly Lower Silurian character.

In the Orthoceras Limestone Graptolites are extremely rare. I have only found a very few fragments of *Phyllograpti* in Dalecarlia and Jemtland. No doubt the physical conditions prevailing in the sea when this limestone was formed were unfavourable for the existence of Graptolites.

Immediately above the *Orthoceras* Limestone there is a series of mostly black schists, which are known almost only from Scania, though they occur also in Jemtland; in the middle provinces of Sweden they are entirely wanting. By Angelin and other writers they have not been distinguished from the other graptolitiferous rocks situated above the *Orthoceras* Limestone, but they contain, undoubtedly, a peculiar fauna, and occupy a much lower horizon than the Upper Graptolitic Schists. I have therefore proposed to name them Middle Graptolitic Schists. Though their stratigraphical and palæontological relations were misunderstood, the Middle Graptolitic Schists have long been known. At an early period Hisinger described from this horizon *Climacograptus teretiusculus* and *Didymograptus geminus* (=*D. Murchisoni*, Beck.). Of other genera *Dicellograptus*[1] and *Dicranograptus* are the most characteristic, though *Diplograptus* occurs far more plentifully. These schists could therefore be termed *Dicranograptus* Schists. Of the genera *Graptolithus* and *Rastrites* I have not found any representatives in them, with the possible exception of one single fragment of *Rastrites*, found in a loose slab seeming to belong to this horizon. The Middle Graptolitic Schists occur also in Norway, where they form the uppermost part of Stage 3 of Professor Kjerulf, and in the Isle of Bornholm, whence some species were long ago described by Geinitz, and where their stratigraphical relations have lately been worked out by Professor Johnstrup. In Britain they have their nearest analogue in the Moffat series.[2]

In the *Chasmops* Limestone Graptolites are rare, though not quite so much so as in the *Orthoceras* Limestone. I have only found species of *Diplograptus* and perhaps of *Climacograptus*.

The *Trinucleus* Schists are also in general poor in Graptolites, but they have usually been confounded with the Upper and Middle Graptolitic Schists, and therefore, erroneously, stated to contain very numerous species of that group. The few species occurring in the *Trinucleus* Schists are almost exclusively confined to the lower beds, which are usually blackish, and petrographically resemble some varieties of the Upper Graptolitic Schists. From that horizon Hisinger described the *Diplograptus pristis*. Of other genera I have only found *Dicellograptus*. In the upper beds, which are usually reddish, and more marly or calcareous, Graptolites are almost totally wanting.

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[1] Though I do not think that Mr. Hopkinson has correctly interpreted the structure of the species referred by him to the genus *Dicellograptus*, they seem to form a very natural and well-defined group.

[2] I should, however, think that the Moffat series, as defined by English geologists, includes also beds equivalent to the lower portion of the Swedish Upper Graptolitic Schists, which is characterized by *Rastrites peregrinus*, *Graptolithus lobifer*, and *sagittarius*, *Climacograptus teretiusculus* and *Diplograptus palmeus*, while in the upper portion *Graptolithus priodon* and *Retiolites Geinitzianus* are the prevailing species. [Mr. Charles Lapworth has shown that the Moffat series is divisible into distinct groups, characterized by distinct species of Graptolites.—H.A.N.]

From the *Brachiopod* Schists no Graptolites are known.

In the Upper Graptolitic Schists they are on the contrary abundant. The general character of their Graptolitic fauna is quite different from that of the older ones. All branched forms, such as *Didymograptus*, *Dicranograptus*, etc., seem here to be wanting. Of diprionidian forms *Diplograptus* and *Climacograptus* still occur, and to them is added *Retiolites*, a genus which has been found in the underlying rocks. The unbranched monoprionidian forms appear in this horizon in great plenty. Of the genus *Graptolithus* numerous species occur, and *Rastrites* is represented at least by two or three. The Upper Graptolitic Schists occur also in the Isle of Bornholm, but are not known from Norway. In Bohemia and Britain they have also very well-marked analogues. The lower portion of Barrande's Stage E and the "colonies" in his Stage D contain a quite corresponding fauna. Among the species common to the Bohemian and Swedish beds are *Graptolithus priodon*, *lobiferus*, and *colonus*, *Diplograptus palmeus*, *Rastrites peregrinus*, *Retiolites Geinitzianus*, and several others. In Great Britain, the Coniston and Gala beds correspond to the Upper Graptolitic Schists of Sweden.

The Upper Graptolitic Schists occur in Westrogothia, Ostrogothia, Scania, and Dalecarlia. In the two first-named provinces they are the youngest Silurian rocks. In Scania they seem to be immediately overlain by Upper Silurian beds, corresponding to the lowest beds of Gotland. In Dalecarlia they are overlain by a limestone peculiar to that province, the *Leptæna* Limestone of Tornquist, or the typical part of *Regio Harparum* of Angelin.[1] In that limestone no traces of Graptolites have been found.

In the Upper Silurian rocks of Sweden, which form the *Regio Encrinurorum* of Angelin, and which I have therefore termed *Encrinurus* Beds, Graptolites are nearly entirely wanting. From Gotland Dr. Lindström mentions in his enumeration of the fossils of that island only a "Graptolites sp." The only fragments I have myself seen are so obscure as not to enable me to determine their generic characters. In the Upper Silurian of Jemtland and Scania I have not found any Graptolites at all. The scarcity of the Graptolites in our Upper Silurian is no doubt in a large part due to the nature of the sediment. In Norway, where schistose beds occur in the higher parts of the Upper Silurian, some species of Graptolites are found plentifully in Stage 8 of Kjerulf, which belongs to the Ludlow formation according to the English classification. The species cited by Kjerulf from that horizon are *Graptolithus Ludensis* and *Retiolites Geinitzianus*. The former might possibly, judging from the figures, include also a *Cyrtograptus*.

The subjoined list will show our present knowledge of the

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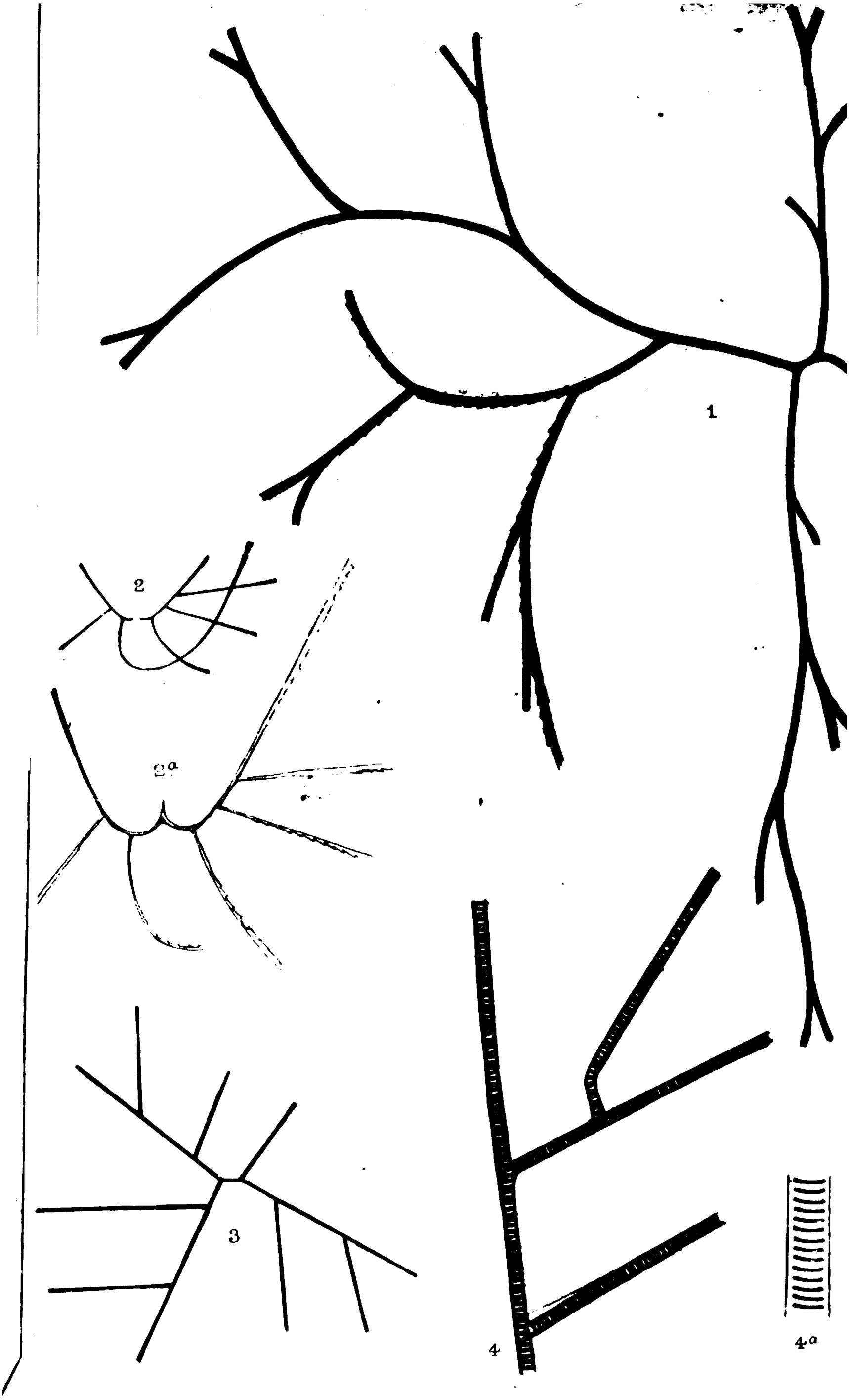
[1] Angelin has erroneously, though with some hesitation, parallelized the *Leptæna* Limestone of Dalecarlia with the *Brachiopod* Schists of Westrogothia and Ostrogothia, and therefore included also the latter in his *Regio Harparum*.



worth del. et lith. W. West & C

Lower Silurian Graptolites.

vertical distribution of the genera of Graptolites in the Cambrian and Silurian rocks of Sweden :—

Genera.	15. Eophyton Sandstone.	14. Fucoid Sandstone.	13. Paradoxides Schists.	12. Olenus Schists.	11. Dictyonema Schists.	10. Ceratopyge Limestone.	9. Lower Grapt. Schists.	8. Orthoceras Limestone.	7. Middle Grapt. Schists.	6. Chasmops Limestone.	5. Trinucleus Schists.	4. Brachiopod Schists.	3. Upper Grapt. Schists.	2. Leptæna Limestone.	1. Encrinurus Beds.
Dichograptus	.....	.....	.....	x	x	.....	x								
Dictyonema	.....	.....	.....	?	x										
Phyllograptus	.....	.....	.....	.....	.....	.....	x	x							
Tetragraptus	.....	.....	.....	.....	.....	.....	x								
Didymograptus........	.....	.....	.....	.....	.....	.....	x	.....	x						
Dicellograptus	.....	.....	.....	.....	.....	.....	.....	.....	x	.....	x				
Dicranograptus........	.....	.....	.....	.....	.....	.....	.....	.....	x						
Climacograptus........	.....	.....	.....	.....	.....	.....	.....	.....	x	.....	.....	.....	x		
Diplograptus........	.....	.....	.....	.....	.....	.....	.....	.....	x	x	x	.....	x		
Graptolithus........	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	x		
Rastrites	.....	.....	.....	.....	.....	.....	.....	.....	?	.....	.....	.....	x		
Retiolites	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	x		

II.—NOTES ON THE CORRELATION OF THE GRAPTOLITIC DEPOSITS OF SWEDEN WITH THOSE OF BRITAIN.

By H. ALLEYNE NICHOLSON, M.D., D.Sc., F.R.S.E.;
Professor of Natural History in the University of St. Andrews.

(PLATE IX.)

THE foregoing paper was sent to me by Dr. Linnarsson, along with a fine collection of Swedish Graptolites; and I am happy to be the medium through which his interesting observations appear before the English public. With singular acumen, the distinguished Swedish geologist has unravelled the intricacies which beset the study of the distribution of the Graptolites in past time; and his results are of peculiar importance and value. Some of these results, in so far as they especially bear upon British Geology, may just be indicated here.

In the first place, Dr. Linnarsson has shown (what British palæontologists have long been trying to prove) that certain species and genera of Graptolites are restricted to certain very definite horizons. He has thus added fresh force to the opinion (which some have regarded as exceedingly doubtful) that the Graptolites may be safely relied upon as guides in stratigraphical arrangement—their value in this respect being at least equal to that of the Trilobites. Secondly, Dr. Linnarsson's researches afford another and a very striking proof of the singularly uniform manner in which Graptolites have been distributed throughout the world at corresponding periods of time—the same zones, with the same genera and species, being certainly recognizable in all regions which have hitherto been properly investigated. Thirdly, by means of the clear and satisfactory series of the *Silurian Rocks* of Sweden, Dr. Linnarsson is able to definitely establish the precise position of certain of the Graptolitic zones of Britain, the exact geological place of which has hitherto been a matter of some dubiety. This is especially the case with the "Upper Graptolitic Schists" of Sweden, which unmistakably correspond with the "Coniston Mudstones" of the North of England. It is highly satisfactory to me to know that Dr. Linnarsson's investigations fully corroborate the view always maintained by Prof. Harkness and myself on this matter—namely, that the "Coniston Mudstones" are indubitably inferior to the true Upper Silurian Rocks.

From a study of Dr. Linnarsson's paper, it will be seen that the following five Graptolitic zones are recognizable in Sweden and Norway:

1. OLENUS SCHISTS and DICTYONEMA SCHISTS, with *Dictyonema flabelliformis*, Eichw., and *Dichograptus tenellus*, Linnarsson. The latter is not a true *Dichograptus*, but belongs, together with the form which I described from the Upper Skiddaw Slates under the name of *Dichograptus gracilis*, to a new genus, which I propose to name *Trichograptus*. The *Olenus* Schists and *Dictyonema* Schists of Sweden may be paralleled, with great probability, with the "Tremadoc Slates" of Wales; and as far as the Graptolites are concerned, may be regarded as a single group.

2. LOWER GRAPTOLITIC SCHISTS.—These beds contain species of *Phyllograptus*, *Tetragraptus*, and *Didymograptus*, and are the undoubted equivalent of the Skiddaw Slates of the North of England and the Quebec group of Canada. This is an interesting point, as the Swedish beds rest upon strata containing unequivocal Lower Silurian fossils; whereas the age of the Skiddaw and Quebec deposits has always been a matter of some uncertainty.

3. MIDDLE GRAPTOLITIC SCHISTS.—These are beyond question the equivalent of the inferior portion of the Moffat series of the South of Scotland (the "Lower Moffat Shales" of Mr. Charles Lapworth). They are characterized by the occurrence of *Climacograptus teretiusculus*, His., and species of *Dicellograptus* and *Dicranograptus*, together with the total absence of species of *Monograptus* and *Rastrites*.

4. UPPER GRAPTOLITIC SCHISTS.—The lower portion of these is equally beyond doubt the precise equivalent of the "Coniston Mudstones" or "Skelgill Series" of the North of England (and of the "Upper Moffat Shales" of the South of Scotland). They are characterized by the absence of *Didymograptus* and *Dicranograptus*, and the presence of species of *Monograptus*, *Rastrites*, *Diplograptus*, and *Climacograptus*. Beds of the same age, and containing the same species of Graptolites, have recently been recognized by Dr. Guido Stache as occurring in Carinthia, and have by him been paralleled with the Coniston Mudstones (Die Graptolithen-Schiefer am Ostering-Berge in Kärnten).

5. UPPER SILURIAN.—Though poorly represented in Sweden, a fifth Graptolitic zone exists (well developed in Norway), which is of *Upper Silurian* age, and is characterized by the occurrence of *Mono-*

graptus priodon, Bron., and *Retiolites Geinitzianus*, Barr. The same species characterize the true Upper Silurian Rocks of the north of England (Coniston Flags and Grits), the Upper Silurian Rocks of the South of Scotland, and the same deposits in Wales. It seems tolerably certain, however, that the *highest* beds of Dr. Linnarsson's "Upper Graptolitic Schists" are truly referable to this fifth zone, and are, therefore, of Upper Silurian age. This seems to be proved by the fact that the beds in question are not only lithologically different from the lower portion of the "Upper Graptolitic Schists," but contain *Monograptus priodon*, Bron., *M. vomerinus*, Nich., and *Retiolites Geinitzianus*, Barr., all of which are characteristic Upper Silurian species in Britain.

It may be as well to give here a list of the Graptolites comprised in the collection kindly sent me by Dr. Linnarsson, and in so doing, I have thought it best in all cases to adhere to the names given by Dr. Linnarsson himself:—

I. Olenus Schists. (Bed No. 12 of List, see p. 245.)

1. *Dichograptus tenellus*, Linnarsson; Westrogothia.

II. Dictyonema Schists. (Bed No. 11 of List.)

1. *Dictyonema flabelliforme*, Eichw.; Scania and Ostrogothia.
2. *Dichograptus* sp.; Scania.

III. Lower Graptolitic Schists. (Bed No. 9 of List.)

1. *Phyllograptus angustifolius*, Hall; Scania and Westrogothia.
2. ———— *typus*, Hall; Scania.
3. *Didymograptus hirundo*, Salt.; Scania and Westrogothia.
4. ———— *striatulus*, Linnarsson (MS.); Westrogothia.
5. ———— sp. (Comp. *D. V-fractus*, Salt.); Scania.
6. *Tetragraptus bryonoides*, Hall; Westrogothia.

IV. Middle Graptolitic Schists. (Bed No. 7 of List.)

1. *Dicranograptus Clingani*, Carr.; Scania.
2. *Dicellograptus* sp.; Scania.
3. *Climacograptus teretiusculus*, His.; Scania.
4. *Diplograpsus pristis*, His.; Scania.

V. Trinucleus Schists. (Bed No. 5 of List.)

1. *Diplograptus pristis*, His.; Dalecarlia, and Ostrogothia.
2. *Dicellograptus elegans*, Carr. (?); Dalecarlia.

VI. Upper Graptolitic Schists. (Bed No. 3 of List.)

1. *Retiolites Geinitzianus*, Barr.; Ostrogothia, and Dalecarlia.
2. *Rastrites peregrinus*, Barr.; Scania, and Dalecarlia.
3. *Graptolithus priodon*, Bronn.; Ostrogothia, and Dalecarlia.
4. ———— *sagittarius*, His.; Westrogothia, and Ostrogothia.
5. ———— *lobiferus*, McCoy; Dalecarlia.
6. ———— *convolutus*, His.; Dalecarlia.
7. ———— *turriculatus*, Barr.; Ostrogothia.
8. ———— *proteus*, Barr. (?); Dalecarlia.
9. ———— *teretiusculus*, His. (=*scalaris*, His.); Westrogothia.

It may not be out of place if I conclude these notes with a brief diagnosis of four generic types which I formerly placed in *Dichograptus*, but which I am now disposed to place in distinct groups:—

a. TRICHOGRAPTUS, Nich.—Frond bilaterally symmetrical, compound and branching, composed of two monoprionidian stipes, which proceed from a triangular sicula, and give origin to a series of simple monoprionidian stipes, which arise solely from the celluliferous side of the main stipes. No disc. Cellules of the type of *Monograptus Nilssoni*, Barr. (Pl. IX. Fig. 2.)

This genus is distinguished from *Dichograptus* proper by the absence of a funicle, and the fact that the secondary branches are given off only from one side of the two main stipes. The frond thus resembles a reflexed *Didymograptus*, the stipes of which give off branches from one side only, and that from their celluliferous aspect. The type of the genus is *T.* (*Dichograptus*) *fragilis*, Nich., from the Upper Skiddaw Slates (Ann. Nat. Hist., ser. 4, vol. iv. pl. xi. figs. 1–3). The *Dichograptus tenellus* of Linnarsson, from the "Olenus Schists," also belongs here.

b. SCHIZOGRAPTUS, Nich.—Frond compound, formed of four principal stipes, which radiate in a cruciform manner from a short central funicle. Each of the primary stipes in turn gives rise to a series of rigid secondary branches, which spring from the same side of the same stipe, nearly at right angles, and apparently do not subdivide. Cellules of the type of *Monograptus sagittarius*, His. No disc. (Pl. IX. Fig. 3.) The genus may be compared to a form such as *Tetragraptus quadribrachiatus*, Hall, in which each of the primary stipes gives off branches on one side. The type of the genus is *S.* (*Dichograptus*) *reticulatus*, Nich., from the Lower Skiddaw Slates (Quart. Journ. Geol. Soc., vol. xxiii. pl. v. figs. 4 and 5).

c. TEMNOGRAPTUS, Nich.—Frond branching and rebranching; composed of four primary stipes, which radiate from a short central funicle, and then divide repeatedly and *dichotomously* at nearly regular intervals. Cellules apparently of the type of *Monograptus sagittarius*. No disc. (Pl. IX. Fig. 1.)

The frond in this genus may be compared to a *Tetragraptus*, in which each of the four main stipes divides dichotomously, the branches thus produced dividing repeatedly in a similar manner. The type of the genus is *T.* (*Dichograptus*) *multiplex*, Nich., from the Lower Skiddaw Series (Quart. Journ. Geol. Soc., vol. xxiii. pl. vi. figs. 1–3). The generic distinctness of this type has previously been recognized by Mr. Lapworth (GEOL. MAG., Dec. 1873); and it is probable that *Graptolithus Milesi*, Hall, may be regarded as belonging to this genus.

d. CTENOGRAPTUS, Nich.—Frond branching and rebranching. Cellules extraordinarily close-set, the cell-mouths running directly across the stipes, as so many linear slits. Base unknown. The type of this genus (which I have only established provisionally) is *C.* (*Dichograptus*) *annulatus*, Nich., from the Lower Skiddaw Slates (Ann. Nat. Hist., ser. 4, vol. ii. pl. xi. figs. 4 and 5). From the characters of the cellules it is certain that this form must be separated from *Dichograptus* proper, from which its mode of branching also distinguishes it; but the materials in my hands are not sufficient for a complete or satisfactory diagnosis. (Pl. IX. Fig. 4.)

For the better understanding of the form of the four above-mentioned generic types, I have added the annexed diagrammatic sketches, from which their leading peculiarities will be readily perceived.

EXPLANATION OF PLATE IX.

Fig. 1.—*Temnograptus* (*Dichograptus*) *multiplex*, Nich. Skiddaw Slates. Nat. size.
„ 2.—*Trichograptus* (*Dichograptus*) *fragilis*, Nich. Skiddaw Slates. Nat. size. Fig. 2*a*. Portion of the same enlarged.
„ 3.—*Schizograptus* (*Dichograptus*) *reticulatus*, Nich. Skiddaw Slates. Nat. size.
„ 4.—*Ctenograptus* (*Dichograptus*) *annulatus*, Nich. Skiddaw Slates. Nat. size. Fig. 4*a*. Portion of a branch of the same enlarged.

III.—SOME CONSIDERATIONS ON THE PROBABLE CONDITIONS UNDER WHICH THE PALÆOZOIC ROCKS WERE DEPOSITED OVER THE NORTHERN HEMISPHERE.

By HENRY HICKS, F.G.S.

(*Continued from page* 218.)

Igneous Action and Metamorphism.—I have already referred to the fact that igneous eruptions were frequent during Palæozoic time. As far as there is any evidence at present, they do not appear to have taken place during the Cambrian Epoch either in Europe or in North America. In Europe contemporaneous tuffs or ashes are found for the first time in the succession in the Arenig rocks; and in America about the same period, or perhaps a little earlier. By referring to the Table, p. 156, it will be seen that the contemporaneous traps also occur only in the areas which had undergone most depression, or where the greatest amount of sediment had accumulated. Sir J. Herschel has urged as a reason for this that the crust after a continued period of depression would descend to a point where the heat would be sufficiently great to melt it through, or to weaken it; and that as a consequence fractures would take place, and there would then be a corresponding rising of heat and fiery matter from below, to that of the accumulation of the sediments.

That a great sea of molten matter occurred at that time at a depth of probably no less than 25 miles, and not more than 60 miles, there can, I think, be no doubt, for in no other way can we account for the gradual depression of so large an area of the Northern Hemisphere, and of the subsequent movements which took place. That the melting point even then, however, could not have been much nearer the surface than 25 miles, is evident from the fact that sediments which were buried at a depth of at least 50,000 feet were scarcely at all altered by the combined heat and pressure to which they were subjected.

In the south-west part of Wales the succession from the base of the Cambrian to the Carboniferous is, as already stated, perfectly continuous, and there is no indication anywhere of a break. The same folds have affected the whole series, and they lie in perfect conformability the one on the other. All the beds also, from the base upwards, where there are no intrusive masses, are free from any of the usual signs of metamorphism, and the fossils are therefore well preserved. The reason why these beds are so little altered may be due to the fact that this area was intermediate in position between the more disturbed and perhaps deeper area of North Wales, and the sloping pre-Cambrian ridge to the south.[1] It was therefore most favourably placed, and was almost out of the influence of the molten matter which elsewhere was being so generally injected among the sediments, and which produced metamorphism everywhere in its neighbourhood. In North Wales all the series show indications, more or less, of being altered by heat, and as volcanos were then active in that region, it is evident that the change is chiefly to be attributed to proximity to these intrusions. The portions of the old pre-Cambrian crust brought up in Pembrokeshire at the base of these unaltered beds are highly metamorphosed, and they were doubtless in this state before they were depressed to receive the Cambrian and succeeding sediments, for every part of this old pre-Cambrian land that has been exposed is found more or less in that condition. As all the Cambrian and Silurian rocks, however, are now consolidated, it is of course important to know what degree of heat is necessary to produce that state only, and what to produce the further change of metamorphism. Fortunately, by watching the effects produced by a trap-dyke in passing through any series, it is possible to arrive at some idea of the amount.

In my paper "On the Occurrence of Phosphates in the Cambrian Rocks,"[2] the change effected by heat derived from a trap-dyke on a sedimentary rock (in the Menevian group) and in its organic contents was shown. The chief alteration produced by the intrusive mass in this rock for a considerable distance on each side was to cause cleavage and a deepening of the colour, to remove carbonate and phosphate of lime and all evidences of such substances as the horny texture of the shell of Brachiopoda, Crustacea, etc.

Now, as these Menevian rocks in Pembrokeshire must have been at a depth of at least 40,000 feet before the movements took place which brought them to the surface at the close of the Palæozoic, it is evident, from the state of the rock at present, and of the organic remains, that the heat at that depth was not sufficient to produce much change in the rock or in the fossils—the shells of the fossils being quite perfect, and apparently unaltered by heat, and phosphate and carbonate of lime present in abundance. This fact, in my opinion, is of more importance, in regard to the seat and depth of internal heat, than any evidence that can be derived from examination of the temperature in mines and deep sinkings at present. For the depth was much greater, and the evidence is derived from an earlier period in the history of the globe. To my mind this evidence tends strongly to prove that the heat has a deep-seated source, and that it is not dependent on actions going on in the outer crust only. Prof. Mohr's recent experiments[3] to show that the rate of increase of temperature diminished in a constant ratio with the depth, do not refute the doctrine of Plutonic heat, or of a great sea of deep-seated fluid, as he supposes; nor do they really lead to the inference that the internal temperature is the result of actions going on in the outer crust. They prove rather, for the depth examined, 4042 feet only, that the increased upper heat may be due entirely to some local or superficial cause, and that the internal heat there is at a sufficient depth not to balance the effects at this comparatively superficial point.

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[1] A portion of the Malvern range is probably in the line of, and formed part of this ridge.

[2] Quart. Journal Geol. Soc., August, 1875.

[3] *Neues Jahrbuch*, 1875, 4th part, p. 371.

The chief conclusions to be derived from the foregoing remarks are, that igneous eruptions in Palæozoic time were chiefly confined to the regions which became first submerged, and the immediate cause of these outbursts seems to have been the weakness of the pre-Cambrian crust at those parts, in consequence of the great depression that had taken place, and from being too thin there to resist the pressure from within, and to bear the weight of the superincumbent mass of soft sediment; that the seat of igneous action at that time was at a very considerable depth, as sediments which were depressed to a depth of from 9 to 10 miles do not indicate that they had been subjected to the effect of any great amount of heat; that sediments which have been buried under 50,000 feet of strata, and which consequently must have been subjected to the conditions of heat and pressure existing at that depth, are found not to be sensibly altered; that in the same rocks the passage of a trap-dyke caused a very considerable change in the mineral ingredients in its neighbourhood; and hence that metamorphism *as a rule* may be assumed to be due to proximity to intrusive matter, or to heat derived from the interior of the earth, and not to pressure.

Climate and Succession of Life.—The influence which the various changes which took place in the earth's crust during Palæozoic time had on the succession and development of life must have been great, and no idea can be formed of the probable order in which progress took place unless these various influences are thoroughly considered. In reviewing these causes, I may be allowed to return to a period but slightly touched upon in this paper, and which, in showing us the very earliest known indications of life, must yield evidence of importance. In the Laurentian rocks which formed the pre-Cambrian continents, we have indications in the beds of limestone of an abundance of marine life of a low type, and in the graphite and iron-ore of vegetation. The graphite is supposed by most authorities to have been derived from algæ or marine plants; but I think that it must have been derived from land vegetation, as it alone seems to have that power or persistency of fibre sufficient to allow such changes to have been produced in any great amount out of its structure. Moreover, if algæ could form beds of this description, surely they would be much more frequent in the succession afterwards, as an abundance of marine vegetation must have prevailed where marine animals such as were then common occurred. Again, the soft cellular structure of the algæ renders them liable to very rapid decay, and hence of solution. The presence at this period of limestone, iron-ore, and graphite, naturally calls to mind the conditions prevalent during the Carboniferous period of Palæozoic time. In the cycle of changes which took place in pre-Cambrian times, we find first great and high continents, with small marine areas in the northern latitudes, and consequently a climate probably of extreme cold. This would, of course, be most unfavourable to life, and if life then existed on the globe, it would be in the areas probably about the Equator, where heat and moisture would favour change and progress. As the continents became depressed, and water spread more freely over the Northern Hemisphere, as we know it did towards the close of the Lower Laurentian, a mild climate would be the consequence, and the marine and land life would in a degree be like that towards the close of the Palæozoic in the next cycle. At the close of the Lower Laurentian, large areas were upheaved, and though they were again partly submerged, other upheavals took place, and the continents were then raised to the state in which they were in before the depression commenced in which the Cambrian rocks were deposited. The first cycle, therefore, in the Northern Hemisphere was unfavourable as a whole to the development and progress of life in the higher latitudes, the first and last parts being periods probably of cold, and the middle only mild and moist, or such as would favour life.

The early Cambrian, for the same reason, was a period unfavourable to life in the higher latitudes; and hence we find that forms of life suitable to the changes which were gradually taking place migrated towards the areas from southern points. That it was a cold epoch is evident from the fact that the pre-Cambrian continents occupied very extensive areas in the higher latitudes, and that they were traversed by mountainous ranges attaining in some cases to great heights. At no time since, unless in the Glacial period, does there seem to have been so much land in the higher latitudes, and it is, therefore, reasonable to suppose that in the earlier stages at least of the epoch the climate was one of great cold. As the land became submerged, a state of gradual transition to a milder climate would be the consequence.

Along with the increasing distribution of water in the Northern latitudes we have indications in the faunas that a change was taking place in the temperature of the seas over those areas. For, in addition to the forms (*Trilobites*, etc.) which were present at first, and doubtless capable of inhabiting seas of low temperature, we find others gradually coming in which could only have lived in temperate or warm seas. The presence of an abundance of corals and certain forms of Cephalopods, towards the close of the Lower Silurian, is strong evidence that by this time, at least, warm currents or seas of moderately high temperature prevailed over the areas to a tolerably high latitude on both sides of the Atlantic.

The warmer or more equatorial points seem to have been the home of the earlier forms of life, and it was there probably that the chief changes in development took place.

From these points they gradually migrated northwards as the conditions became favourable, and the groups as they successively appeared always contained evidence of advance in development over those which had previously reached the areas.

In the Cambrian and Lower Silurian deposits, the lines of migrations of the faunas are easily followed out, for they advanced generally along areas of deepest submergence only; and even after most of the land had been completely submerged, the tendency in the faunas to follow the former lines is still shown in the appearance of the higher forms of marine life (Vertebrates) in earlier rocks over the western areas of Europe than in the more eastern areas.

The Devonian Epoch is the first stage in the succession which gives decided proof of how far life on the land had progressed contemporaneously with marine life. The advance made in land life does not seem to have been much behind that in the sea, and it is evident that it had been going on gradually on the portions of the old land remaining above the water, and that it had attained this state by successive steps in the long ages indicated by the Laurentian, Cambrian and Silurian periods. At the time the pre-Cambrian continent commenced to subside, the climate was probably too severe to allow vegetation to have progressed to any great extent on lands in the higher latitudes; but as the land became depressed and the climate milder, the portions still above water became clothed with abundant vegetation, and inhabited by the lower forms of terrestrial life. All these facts tend to show that life on land and in the sea progressed chiefly in warm areas, and that the northern latitudes were not on the whole favourable in the earliest time to this progress. This is the explanation to my mind why the record is not more perfectly preserved to us in these northern regions, which, from these very circumstances of repeated change, is almost the only one now open to our examination.

IV.—ON THE THEORY OF THE EROSION OF LAKE-BASINS BY GLACIERS.

By Mr. O. FISHER, Clk., M.A., F.G.S.

IT is now more than eleven years since I ventured to take a part in the discussion then raised by Professor Ramsay having lately published his celebrated theory of the Erosion of Lake-Basins by the lower ends of Glaciers, where they may have formerly expanded over a more level country, beyond the confines of their parent valleys. It appears to be admitted that a great many lakes lie in positions where it would be natural to suppose them so formed, if only glaciers could have possessed the erosive powers necessary for the purpose. The positions of the deeper parts of the lakes also accord well with the theory.

Mr. Bonney, than whom there are few, if any, more competent glacialists, says, in the last Number of this MAGAZINE (p. 197), that his late observations have confirmed him in "regarding a glacier as an agent of abrasion rather than of erosion," and that, "where the ice rests on the level or stony plain," the subjacent materials, so far as he could make out, "are little if at all disturbed"; and he "feels convinced great caution must be exercised in referring to their action a rock-basin of even moderate dimensions." Without in any degree questioning the correctness of Mr. Bonney's observations, or of his direct conclusions from them, it still seems that the possibility of the erosion of a great lake by a glacier has not been disproved. For the assumption made by Professor Ramsay of the immense extension of the ice, brings the case under wholly different conditions from any which can be now *observed*, because the present Swiss glaciers do not extend over such localities as would be favourable to the excavation of lakes, and, even if they did so, observations made at their edges could tell us little of what may have gone on beneath the central parts of a considerable ice-field.

It is satisfactory to find that Mr. Bonney gives the weight of his authority to uphold Forbes's opinion that ice is plastic. There can be no doubt that, when sufficient masses are under consideration, and sufficient time is allowed, it affects on a large scale the movements of a liquid under the action of gravity. Thus, if two portions of glacier ice of unequal height were placed side by side in a containing hollow, the more lofty mass would have its lower parts pressed out laterally into the lower parts of the other, raising its surface until the two become sensibly of the same height. Hence we see two tributary branches of a glacier unite to form one trunk glacier of a uniform level, whose surface obeys the same laws of form as that of a river, swelling slightly above the general plane where the supply of material is more rapid, and the motion greater. Hence also a glacier fills successively the narrower and wider portions of its bed. But this accommodation of the form to the requirements of gravity is a slow process; as is shown by the ice-walls, exposed for some distance where the glacier has lately passed a projecting cape of rock; for at such a place the ice has already a longitudinal motion; while the transverse motion, in virtue of which it eventually fills the wider channel, has to be set up *de novo* after it has passed the narrow.

This is the source of the so-called *vis a tergo*. For the tendency of the ice, descending its rocky channel, is to heap itself up at any point, until, becoming too heavy to be supported by the rigidity of its parts and the friction of its rocky bed, and pressing outwards in all directions, it is constrained to move forwards, and, if there be liberty to do so, also sideways, since it cannot force back the weight behind it.

Let us suppose that, under the influence of this pressure, the end of the glacier is expanded over a comparatively plane country. And perhaps the simplest mode of considering whether it could excavate a lake-basin will be to consider a basin already existing, and to inquire whether it would be competent to deepen it. For if it could do that, no doubt it could originate it.

My object then in writing this is to refer to what seems to me a point of great importance which I put forward in my second letter to the *Reader* of April 9, 1864, and which I do not remember to have seen adverted to in any of the discussions on this question. If ice were to fill a lake-basin, it must necessarily be under hydrostatic pressure; that is, there must be a stratum of water, more or less, between it and the bottom of the rock-basin. This circumstance seems to have been lost sight of. It would be necessary for the ice to rise to a certain height above the level of the outlet of the basin, in order to allow it to touch the bottom anywhere; and wherever it did so, it would be thawed by contact with the rock, and so a continual circulation of water would be kept up from even the deepest parts of the basin towards the outflow. Hence, in addition to any abrading power which might be exercised by the motion of the ice, through means of the stones and grit in it, or between it and the rock, there would be a certain amount of water action besides, carrying away at once all the minutely divided particles, such as we now see to render glacial streams turbid, and also hurrying through the channels where the contact of the ice and rock was less close, and there exercising the ordinary abrading power of water.

It is not very easy to determine by what course the main volume of water, which formed the sub-glacial river before it reached the lake, would make its passage through it. If the height of the ice above the outflow was so great, that the ice was kept pressing on the bottom, the river must have found its channels along the sides of the lake, thus tending to widen it. But if the thickness of the ice was not sufficient for that, it would flow underneath. In any case, the greater portion of the basin being occupied by ice, the water channels must have been greatly confined, so that it is very probable that the streams among the ice masses would have been sufficiently rapid to have exercised an abrading power of their own. Besides this, if the masses of ice were too lofty in proportion to the depth of the basin to be floated, the water, when occasionally pounded back by them, would force them along the bottom: reproducing on a small scale the phenomena of a grounded ice-pack. At any rate, it appears that the presence of this water ought greatly to modify the conditions of all reasoning upon this interesting question.

V.—SKETCH OF THE GEOLOGY OF ICE SOUND AND BELL SOUND, SPITZBERGEN.

By Professor A. E. NORDENSKIÖLD, of Stockholm;
For. Corr. Geol. Soc. Lond.

PART IV.

(*Concluded from the March Number, page* 127.)

VIII. *Cretaceous Beds.*—During our previous Expeditions we had not fallen in with any strata belonging to this period on Spitzbergen; but in the beginning of the Expedition of 1872 I had the good fortune to supply this missing link in the geology of Spitzbergen through the very unexpected discovery, in the immediate neighbourhood of the Taxodium strata at Cape Staratschin, of fossil plants, which had an unmistakable reference to the fossils which I brought home some years ago from Kome in Greenland (Lower Cretaceous). A closer examination by Professor Heer showed that this supposition was so far correct, inasmuch as the strata in question truly belonged to the Cretaceous series, though occupying a position more recent than the Kome strata in Greenland.

The outermost part of the peninsula, which in our more recent maps of Spitzbergen is named Cape Staratschin, is known among the whalers by the name of "the Fastness" (Fästningen), on account of a high sandstone ridge, which here, like a wall built by human hands, runs for some distance over the low flat close to the shore, and then projects into the sea, forming a rocky island with precipitous sides shaped like a parallelopiped separated from the main land by a small sound. This "wall" is formed of a vertical stratum of a very hard quartzite-like sandstone, which has withstood better than the surrounding strata the disintegrating action of the atmosphere, the ice and the frost. It forms there the boundary between the Jurassic and the Cretaceous strata. Close to the outer side of this sandstone ridge are to be found schistose strata with Jurassic fossils (*Aucella mosquensis, Belemnites, Ammonites triplicatus ?*), and close to the inner side a grey sandy schist with chalk fossils. At the outermost point, there is to be seen, on the inner side of the vertical sandstone stratum, the impression of a tree-stem 5 metres high and 0·3 metre broad, which, to judge from the way in which it has been pressed together, belonged to some hollow-stemmed plant, or some plant with a *soft* woody tissue, and the same sandstone bed is strewn over with large but indistinguishable vegetable remains. On a closer examination of the surrounding strata, I had the good fortune to find in addition impressions of plants which could be determined. These occur most abundantly in a greyish black, moderately hard sandy schist, which forms vertical strata immediately within the quartzite or sandstone stratum just mentioned. The number of the species which Heer could determine is sixteen, namely :—

A. FERNS.

1. *Asplenium Johnstrupi*, Heer.
2. *Asplenium Boyeanum*, Heer.
3. *Sphenopteris hyperborea*, Heer.
4. *Thinfeldia arctica*, Heer.
5. *Sclerophyllina cretosa*, S.

B. EQUISETACEA.

6. *Equisetum* sp.

C. CONIFERS.

7. *Phyllocladites rotundifolius*, Heer.
8. *Araucarites Nordenskiöldii*, Heer.[1]
9. *Sequoia Reichenbachi*, Gein., sp.
10. *Sequoia rigida*, Heer.
11. *Sequoia fastigiata*, S.
12. *Pinus Peterseni*, Heer.
13. *Pinus Quenstedti*, Heer.
14. *Pinus Staratschini*, Heer.
15. *Pinus* sp.

D. MONOCOTYLEDONS.

16. *Hypoglossidium antiquum*, Heer.

2 indeterminable species.

Of these species, six occur in the Lower Cretaceous strata of Greenland (Kome strata), and seven in the Upper Cretaceous strata (Atane strata), whence Heer comes to the conclusion that the Cretaceous strata at Cape Staratschin have been deposited during the middle of the Cretaceous Period. The most common fossil consists of branches, ♂-flowers, and cones of *Sequoia Reichenbachi*.

Among the Conifers enumerated by Heer, there is a very large cone of *Araucarites*. This, however, was not found at "the Fastness," but four to five kilometres further east, at the entrance to Green Harbour, and likewise in the neighbourhood of a hard sandstone stratum, which probably forms a continuation of that just mentioned.

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[1] This species is from another locality. See below.

Between these two localities for Cretaceous plants there lies the Taxodium bed, so extraordinarily rich in Miocene impressions of plants, whose fossils have been described by Heer, in "Die Miocene Flora und Fauna Spitsbergens," Vet. Akad. Handl. B. 8, No. 7. It is, however, very difficult to make out where the boundary ought to be drawn between the Miocene strata and the Cretaceous strata; and it is possible that a considerable part of the greenish-grey sandstone, which forms the high ridge, rising to a height of 2000 feet, between Green Harbour and Advent Bay, and which I have looked upon as Miocene, has been deposited during the Cretaceous period. These strata do not contain any fossils by which to determine with certainty their age. The foot of the mountain itself is formed in all probability of Jurassic strata. There occur in many places, for example near the sea-shore between Advent Bay and Coal Bay, in the precipitous shore-terrace, upwards of 1000 feet high (steep and dangerous from the falling down of stones), inconsiderable horizontal coal-seams, whose age indeed cannot with certainty be determined, in consequence of the absence of fossils; but the hard sandstone, which incloses the coal-seam, corresponds so completely with the sandstone at Cape Boheman, that there is a strong probability that this is a continuation of the Jurassic strata occurring at the promontory just named.

IX. *The Miocene Period.*—Strata containing Miocene vegetable impressions have been found in Spitzbergen, both in King's Bay and in many places in Ice and Bell Sounds. At many of the localities the strata belonging to this age are of limited extent, inasmuch as they consist only of local formations deposited in hollows between the high ridges formed of older rocks. At others again, for example Heer's Mountain on Ice Sound, and Coal Mount and Sundevall Mountain on Bell Sound, the high ridge itself is believed to have been wholly formed during this period, and perhaps this is also the case with a great part of the high ridge between Ice and Bell Sounds. It is only possible, however, to determine with perfect certainty those strata to be Miocene which contain fossils belonging to that period. Such strata have been found at the following places:—

King's Bay.[1]—The Coal Harbour. These strata have been already completely described by Blomstrand and myself, and I will therefore, in respect to them, merely remind the reader that they are strongly dislocated, or perhaps more correctly compressed, in a basin-shaped hollow in the older rock formations. The strata consist of sandstone, clay-slate, and three coal-seams.

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[1] In "Die Miocene Flora und Fauna Spitsbergens von Oswald Heer," the following species taken from this locality are mentioned:—

Sphenopteris Blomstrandi, Hr.
Equisetum arcticum, Hr.
Thuites Ehrenswärdi, Hr.
Juniperus rigida, Hr.
Pinus Abies, L.
Poacites Torelli, Hr.
Naias stricta, Hr.
Sagittaria hyperborea, Hr.
Iris latifolia, Hr.
Populus Richardsoni, Hr.
Nymphæites Thulensis, Hr.
Tilia Malmgreni, Hr.
Carpolithes oblongus, Hr.

With the exception of *Equisetum arcticum*, which forms the great mass of the fossil plants of this locality, these species occur only in single examples.

2. *The Taxodium Strata at Cape Staratschin.*—At this place, too, the Miocene strata only fill up an inconsiderable hollow between the sandstone belonging to the Cretaceous series, which occurs at *the Fastness*, and at the same rock at the entrance to *Green Harbour*. Close to the Taxodium slate in the rocky shelf, near the shore, we have the following section:—

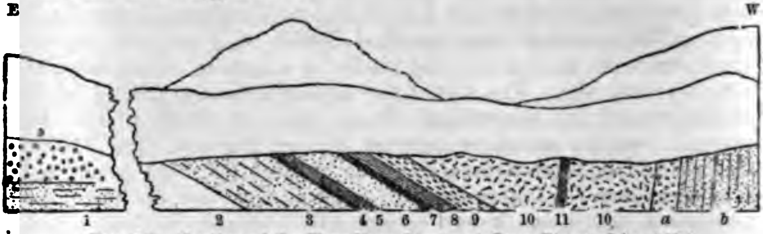

FIG. 14.—Section of the Taxodium Strata at Cape Staratschin, 1872.

1. (Lowermost). Grey sandstone, with thin beds of slate.
2. Coarse conglomerate, 8 metres.
3. Grey coarse sandstone, with beds of slate and leaf impressions, 17 metres.
4. A thin coal-seam, 0·1 metre.
5. A fine clay-slate (Taxodium slate), exceedingly rich in beautiful and well-preserved fossils, 0·7 metres. The distance of this important locality from the sandstone ridge at the Fastness is 520 metres.
6. Grey coarse sandstone with leaf impressions.
7. Coal, 1 metre.
8. A pretty hard marl-slate, 2 metres.
9. Grey sandy shales, 2 metres.
10. Part not exposed.
11. Coal-seam, probably a continuation of seam 7.

Further on west, towards the sandstone ridge, the strata were covered by gravel and snow drifts; still farther we met with a nearly vertical conglomerate stratum *a*, probably a continuation of stratum 2, and then vertical strata of sandstone and slate *b*, showing at some places uncommonly well-marked tracks of the action of waves. It is possible that these strata belong to the same series as those which at the sandstone ridge close at hand contain Cretaceous plants.

I had already visited this place during the Expedition of 1858, and I then found here the first fossil plants from this locality, namely, some small petrified stems and branches, also fragments of shells imbedded in a conglomerate bed two to three inches thick, which I have not since met with again. The fossil plant-remains are described by Professor C. Cramer in Heer's *Flora fossilis arctica*, Del. i. s. 175. The fragments of shells consist of mere *fragments* of sea-shells, probably washed out of some older strata. Some paces east of the Taxodium strata, there is a stratum of impure clay ironstone, containing *Nordenskiöldia arctica*, Heer, *Sparganium crassum*, Heer, and *Helleborites marginatus*, Heer. The position of this stratum in the series just described I have not been able to determine.

Stratum 5 (the Taxodium stratum) cannot, indeed, be compared with the strata at Cape Lyell for absolute richness in fossil plants, *but on the other* hand it exceeds both the strata just mentioned and all the other localities on Spitzbergen in richness in species. The only disadvantage is, that the slates are here so loose and split up by frost, that it is impossible to obtain even a piece with a few square inches of surface, except by a considerable removal of the broken fragments of rock.

From this locality (the Taxodium slates and the sandstone lying in its immediate neighbourhood), Heer enumerates the following species:

A. Mushrooms.

1. *Sphæria annulifera*, Heer.
2. ,, *pinicola*, Heer.
3. ,, *hyperborea*, Heer.

B. Algæ.

4. *Münsteria deplanata*, Heer.

C. Mosses.

5. *Muscites Berggreni*, Heer.

D. Ferns.

6. *Adiantum Dicksoni*, Heer.

E. Conifers.

7. *Taxodium distichum miocenum*, Heer; exceedingly common, a plant type still surviving in Texas.
8. *Libocedrus Sabiniana*, Hr.; common.
9. *Libocedrus gracilis*, Heer.
10. *Sequoia Nordenskiöldi*, Heer; common
11. *Sequoia brevifolia*, Heer.
12. *Pinus montana*, Mill.
13. ,, *polaris*, Heer.
14. ,, *cycloptera*, Sap.
15. ,, *stenoptera*, Heer.
16. ,, *macrosperma*, Heer.
17. ,, *Ungeri*, Endl.
18. ,, *Abies*, Linn.
19. ,, *Loveni*, Hr.
20. ,, *Dicksoniana*, Hr.
21. ,, *Malmgreni*, Hr.
22. ,, *impressa*, Hr.
23. *Taxites Olrichi*, Hr.
24. *Torellia rigida*, Hr.
25. ,, *bifida*, Hr.
26. *Ephedrites Sotzkianus*, Ung.

F. Monocotyledons.

27. *Phragmites Œningensis*, Alex. Br.
28. *Poacites arenaceus*, Hr.
29. ,, *hordeiformis*, Hr.
30. ,, *Friesianus*, Hr.
31. ,, *læviusculus*, Hr.
32. ,, *effossus*, Hr.
33. ,, *sulcatus*, Hr.
34. ,, *parvulus*, Hr.
35. ,, *Torelli*, Hr.
36. ,, *lævis*, Hr.
37. ,, *argutus*, Hr.
38. ,, *trilineatus*, Hr.
39. ,, *bilineatus*, Hr.
40. ,, *lepidulus*, Hr.
41. *Cyperus arcticus*, Hr.
42. *Carex Andersoni*, Hr.
43. ,, *Berggreni*, Hr.
44. *Carex hyperborea*, Hr.
45. ,, *misella*, Hr.
46. ,, *antiqua*, Hr.
47. *Cyperites strictus*, Hr.
48. ,, *argutulus*, Hr.
49. ,, *trimerus*, Hr.
50. *Juncus antiquus*, Hr.
51. *Acorus brachystachus*, Hr.
52. *Potamogeton Nordenskiöldi*, Hr.
53. *Sagittaria difficilis*, Hr.
54. *Iridium grœnlandicum*, Hr.

G. Dicotyledons.

55. *Populus Richardsoni*, Hr.
56. ,, *Zaddachi*, Hr.
57. ,, *arctica*, Hr.
58. *Betula prisca*, Ettingh.
59. ,, *macrophylla*, Goepp. sp.
60. *Corylus McQuarrii*, Forb. sp.
61. *Quercus grœnlandica*, Hr.
62. ,, *platania*, Hr.
63. ,, *venosa*, Goepp.
64. *Platanus aceroïdes*, Goepp.
65. *Polygonum Ottersianum*, Hr.
66. *Salsola arctica*, Hr.
67. *Elæagnites campanulatus*, Hr.
68. *Cypselites sulcatus*, Hr.
69. ,, *incurvatus*, Hr.
70. *Andromeda protogæa*, Ung.
71. *Fraxinus microptera*, Hr.
72. *Viburnum Whymperi*, Hr.
73. ,, *macrospermum*, Hr.
74. *Hedera MacClurii*, Hr.
75. *Cornus hyperborea*, Hr.
76. *Nyssa europæa*, Hr.
77. *Nyssidium Ekmani*, Hr.
78. ,, *crassum*, Hr.
79. ,, *oblongum*, Hr.
80. ,, *fusiforme*, Hr.
81. ,, *lanceolatum*, Hr.
82. *Helleborites marginatus*, Hr.
83. ,, *inæqualis*, Hr.
84. *Nymphæa arctica*, Hr.
85. *Paliurus Colombi*, Hr.
86. *Rhamnus Eridani*, Ung.
87. *Sorbus grandifolia*, Hr.
88. *Cratægus Carneggiana*, Hr.
89. *Rubus scabriusculus*, Hr.
90. *Prunus Staratschini*, Hr.
91. *Leguminosites vicioides*, Hr.
92. *Phyllites hyperboreus*, Hr.

93–112. Twenty different kinds of seeds (*Carpolithes*).

The black slate at *Cape Staratschin* also contains 23 species of insects, among which are 20 Coleoptera.

3. *Cape Heer.*—Leaving the strata marked 1 and 2 in the profile given above, and advancing along the steeply-sloped shore terrace, 20 to 30 feet high, eastwards towards Green Harbour, we pass first a number of strata of slate and sandstone, mostly vertical, but sometimes also horizontal or bent in saddle form, in which I could not find any other fossils than a piece of shale of considerable size with an impression of *Iris latifolia*, Heer. Nearer Green Harbour there occurs again a hard sandstone, overlain by a black sandy slate, in which the cone of *Araucarites* before mentioned was found. Farther inwards there is a low flat, through which runs the so-called Russian River, which a short distance from the shore cuts through the strata belonging to the Jurassic formation. East of Green Harbour there are, however, to be found other Miocene strata, namely, at Cape Heer. The succession of strata at this point are as given below:—

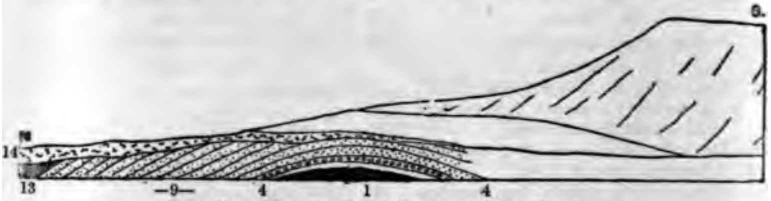

Fig. 15.—Profile of Strata at Cape Heer.

1. (Lowest) A Coal-seam lying at the water's edge, from which the whale fishers who visit this region obtain the little supply of fuel which they require for cooking, 1 metre.
2. Black slates with trace of Taxodium, 0·4 m.
3. Coarse and irregular sandstone, with impressions of some leaf-trees, 0·1 m.
4. Coarse-grained conglomerate, consisting of flint nodules closely agglomerated, varying in thickness from 2·5 to 6 m.
5. Sandstone mixed with clay, pretty rich in vegetable impressions, 1·3 m.
6. Evenly splitting sandstone without vegetable impressions, 7 m.
7. A thin seam of Coal, lying in clay-slate and a loose gravelly sand. The three strata together, 1·5 m.
8. Hard, evenly splitting sandstone, 10 m.
9. Hard sandstone, with very large, ill-preserved plant impressions (similar to the sandstone from the ravine on the Coal Mount on Bell Sound), 2 m.
10. Conglomerate, 0·3 m.
11. Sandstone irregularly stratified, alternating with small limestone seams. The sandstone contains here and there black spots resulting from inconsiderable remains of plants, 7 m.
12. Sandstone irregularly stratified and joined with inconsiderable plant impressions, 20 m.
13. Sandy clay-slate, in which I found two impressions of mussels, which, however, it was impossible more completely to determine, 25 m.
14. Recent gravel, washed down from the mountain, which covers the series of strata just described.

The fossils in these strata are commonly ill-preserved, and cannot be compared with the vegetable impressions from the Taxodium strata at Cape Staratschin. A complete description by Heer will be given in the "Transactions of the Academy of Science" (Stockholm). In some preliminary notices of the fossil plants collected by us on Spitzbergen in 1872 and 1873 (Öfvers. af Vet. Akad. Förh. 1874, *s. 32), Heer* says of the plants from this place:—"There occur most commonly *Populus arctica*, Hr., also *Taxodium ;* fragments of the leaves of *Platanus aceroïdes*, Goeppert, *Sorbus ? grandifolia*, Hr., *Equisetum, Phragmites, Cyperacites*, and *Quercus*." The Coal-seam here is, on the other hand, the best I know on Spitzbergen.

As the strike of the strata is very nearly the same as the direction of the Sound, and they dip 5° to 10° towards Coal Bay, it is probable that the high ridge in the neighbourhood consists of more recent beds than the Miocene strata at the shore. Unfortunately I could not on this opportunity examine them more closely. It is, however, highly probable that such is the case from the formation of Heer's Mountain lying on the other side of the valley in the bottom of the fiord.

4. *Heer's Mountain.*—During the Expedition of 1861 Blomstrand found here Miocene fossil plants, among them *Platanus aceroïdes*, Goepp., in the neighbourhood of a coal-seam at a height of 200 metres above the sea. It was, however, impossible to institute a closer examination of the place, on account of the gravel which had fallen down from the mountain, and at the time was hard frozen.

5. *The Coal Mount* on the north shore of Van Mijen Bay in Bell Sound. (See Woodcut, Fig. 16.)

a. Locality for Miocene vegetable remains.
b. An inconsiderable coal-seam.
c. Loose sandstone strata, with a few impressions of *Taxodium*.
d. Hard sandstone, with large indistinct impressions of plants.

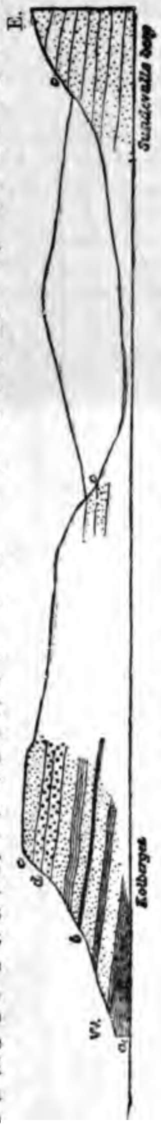

FIG. 16.—Section of the Tertiary Strata on the North Shore of Van Mijen Bay.

The first Miocene plants from Spitzbergen were discovered by me in 1858 (at *a* in the figure), in a black sandy slate, easily split up, and alternating with seams of sandstone, in solid rock about the middle of the shore terrace on the south-west side of the mountain. This slate is overlain a little way from the shore by a greyish-white sandstone, in nearly horizontal layers, rather hard at the beginning, but higher up very loose, which, alternating with seams of slate, occupies the whole of the Coal Mount, and of Sundevall's Mountain, which lies farther up the fiord. The whole forms a series at least 360 metres thick of Miocene or Post-Miocene strata, a closer examination of which may, perhaps, throw important light on the passage from the Miocene to more recent periods. Although I have myself visited the place three times, I have not had opportunity to make such an examination, and in 1864 and 1872 I was unable to find again the fossiliferous stratum at the foot of the mount.

The number of the species from this stratum described by Heer goes up to eight, among which is a *Potamogeton.* I have besides at Coal Mount found fossil plants in a hard sandstone (*d*), which together with a conglomerate layer intersects the looser sandstone about the middle of the mount. This hard sandstone stratum is accessible in a stream-ravine on the north side of the mount. It is clearly identical with stratum No. 9 at Cape Heer, and here, as there, the hard sandstone of Bell Sound is rich in large plant remains, very few of which, however, can be accurately determined. The following species are found at this locality:

GENERA AND SPECIES.	Strata at the Sea-shore.	Upper Strata at Coal Mount.	The Ravine.
Filicites deperditus, Hr.	—	—	x
Taxodium distichum miocenum, Hr.	x	x	x
Pinus polaris, Hr.	x	—	—
Potamogeton Nordenskiöldi, Hr.	x	—	x
Populus Richardsoni, Hr.	x	—	—
Salix macrophylla (?), Hr.	x	—	—
Alnus Käfersteini, Goepp	x	—	—
Corylus McQuarrii, Forb.	x	—	—
Fagus Deucalionis, Unger	x	—	—

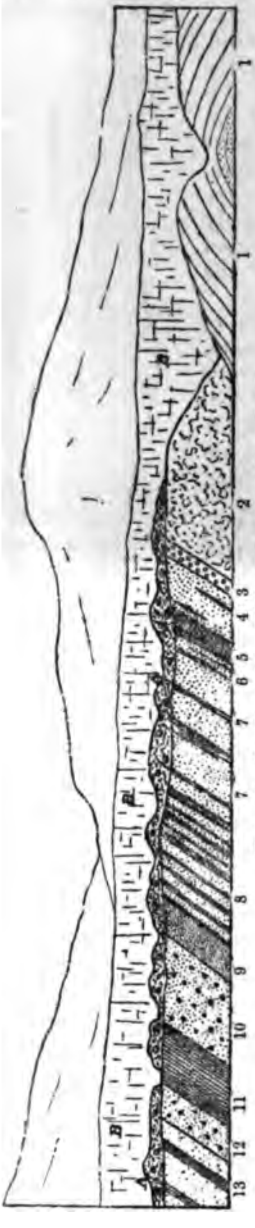

FIG. 17.—Section of the Miocene Strata at Cape Lyell.

6. *Cape Lyell.*—The Miocene strata at this place form a real fossil herbarium, which in richness in fine and well-preserved fossil plants is comparable with the richest localities known to man. Here, too, the shore rocks, precipitous towards the sea, afford a beautiful section of the strata. (See Fig. 17.)

1. Breccia, of quartz and mica-schist, with an intercalated stratum of pretty loose sandstone, both probably belonging to the Hecla Hook formation.
2. Strata covered with debris.
3. Inconsiderable conglomerate strata.
4. Loose sandstone, with coal-seam.
5. Clay-slate, with inconsiderable coal-seam.
6. Sandstone, mixed with clay, rich in indistinct plant impressions, 1·3 metre.
7. Sandstone, interstratified with seams of slate. In the sandstone there are at some places intercalated conglomerate beds which contain *rounded pieces of coal.* The strata are rich in plant impressions, which, however, are not so finely developed as in the following divisions. 30 m.
8. An alternation, at least ten times repeated, of a loose clay-slate and sandstone, sometimes interstratified with small seams of coal and lignite. There are drops of retinite interspersed both in the

coal and especially in the lignite. The fossils are extraordinarily fine, and are found chiefly in the neighbourhood of the coal and lignite beds, less beautiful in the sandstone, which instead is crossed throughout by *root fibres converted into coal.* On the boundary with 9 there is a coal-seam of 0·1 metre thickness. 40 m.

9. A pretty hard sandstone, without fossils, and divided from the next stratum by a coal-seam half an inch thick. 2 metres.

10. Hard sandstone, inclosing *rounded pieces of coal, containing retinite.* Without plant impressions.[1] 6 m.

11. Clay, or exceedingly loose slate, containing impressions of Taxodium, etc., which, however, in consequence of the loose condition of the stratum, could not be removed. 10 m.

12. Hard sandstone, containing rounded pieces of coal with retinite. 6 m.

13. Thick beds of sandstone and clay, with inconsiderable plant impressions.

These strata are continued with repeated alternations as far as the neighbourhood of Scott's Glacier. The steeply-sloped shore-terrace is, however, here often covered with snow or gravel, so that I could not with certainty make out whether we have here to deal with a continuation of the strata, or only with the same strata contorted.

A section at right angles to the shore at Cape Lyell approximates to the following (see Fig. 18):

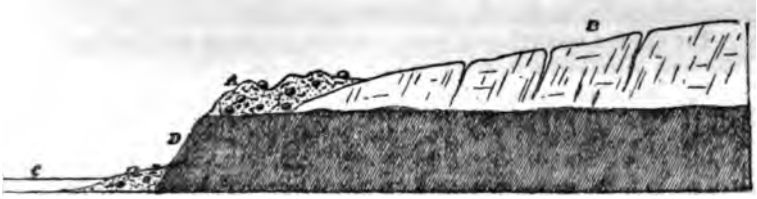

FIG. 18.—Cross-section of the Shore-terrace at Cape Lyell.
A. Moraine. *B.* Glacier. *C.* The Sea. *D.* Miocene Strata.

The summit of the rocks along the shore is formed of an extensive moraine, which gradually passes into a glacier made nearly quite black by earth. The latter is possibly *advancing,* and in that case, perhaps, the fossiliferous strata, the interesting evidence of the climate prevailing in the polar regions in remote ages, will be completely concealed by the ice.

7. *Scott's Glacier.*—Farther inwards the shore of Recherche Bay is occupied by a thick glacier, which slopes steeply towards the sea, and is intersected by innumerable glacier-streams. One of these falls into the sea north of the glacier, and flows, before it reaches the sea, between the loose Tertiary strata, of which the low land consists. In the bank of the stream thus formed there is, about two hundred feet from the shore, a mass of fossil plants, which, however, are not so fine as the fossils at Cape Lyell. The strata themselves are besides covered by ice, clay and gravel, so that no continuous profile can be obtained. A slight advance of the glacier would also at this place be sufficient completely to conceal the locality with a covering of ice.

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[1] This occurrence of rounded pieces of coal, containing retinite, and probably formed during the Cretaceous period, is an interesting evidence of the immense extent of time which must have passed since the coal-seams began to be formed in Spitzbergen. I discovered a similar stratum during the Expedition of 1858, though I then viewed it as post-Miocene, on account of the pieces of coal containing retinite inclosed *in the sandstone,* which I then believed to be Miocene.

A complete description of the fossils from Cape Lyell and Scott's Glacier will be published in a future issue of the Transactions of the Academy of Science (Stockholm). In the preliminary notices quoted above, Heer says: "The most common tree species at Scott's Glacier were *Populus arctica* and *Taxodium distichum miocenum.* Of Conifers there occur, besides the last named, *Glyptostrobus Europæus*, a *Sequoia*, and a *Pinus.* Of the last-named tribe only the common pine is met with, while in the Miocene slates at Cape Staratschin, a great number of species occur.

"*Monocotyledons* are represented by grasses and *Cyperacea*, which probably grew in bogs, together with the poplars and Taxodium.

"Of deciduous trees and bushes we may name *Populus* (three species), *Betula, Corylus, Platanus, Tilia, Cornus, Acer* and *Sorbus.* The planes and lime-trees are remarkable for their large leaves; pieces of bark of the former fallen off are besides not uncommon. There is also a number of leaves, which can only be determined by a minute examination. Some of them belong to the group, whose place in the system cannot be considered settled, and which I have brought together under the name *Pterospermites.*

"The species occurring in preponderating number at Cape Lyell is *Taxodium distichum miocenum,* whose pretty and well-preserved leaf-bearing branches occupy whole blocks of stone. Here accordingly had grown a Taxodium-wood, and we thus anew become acquainted with the fact that this remarkable tree, which yet survives in the marshy regions of the southern part of the United States, during the Miocene period was one of the most common plants of the Arctic Zone. We had already obtained the same plant from Bell and Ice Sounds; while the *Glyptostrobus Europœus*, which is not uncommon at Cape Lyell, was not discovered on Spitzbergen before 1873. This plant increases the number of the species which require a warmer climate than that which I formerly (in the first volume of Flora Fossilis Arctica) supposed to have been prevailing on Spitzbergen during the Miocene period.

"Of deciduous trees and bushes there occur at Cape Lyell the genera *Populus, Alnus, Quercus, Corylus, Fagus, Platanus,* and *Hedera,* with species, which have been already described by me from Spitzbergen, but of which in most cases much finer and more complete leaves have been found. Of some tribes there occur new species, as of *Cornus, C. orbifera,* Hr., and of *Salix* and *Rhamnus.* The genera not before found on Spitzbergen are: *Carpinus, Ulmus* (*U. Fischeri,* Hr.), *Grevia* (*G. crenata,* Ung. sp.) and *Acer.* Two species of maples, remarkable for their beautiful lobate and toothed leaves, occur commonly; fruits of one species also occur. *Grevia* leaves are the most common at "Hohen Rhonen" (Lower Molass in Switzerland), and it is worthy of notice that the leaves from this locality, with respect to the condition in which they have been preserved, completely correspond to the leaves from Cape Lyell. A remarkable fruit, which is uncommon here, is *Nyssa Arctica,* Hr., which formerly was only found in North Greenland, and which stands in close relationship with *N. ornithobroma,* Ung., from the German Brown Coal Beds.

"As at Scott's Glacier, there occurs also at Cape Lyell a number of leaves, whose determination demands a much closer examination than I have been hitherto able to give them. A more complete description of these we must therefore defer."

As the above profiles show, the Tertiary strata on Spitzbergen are very irregularly dislocated and contorted, although they are surrounded by older rocks, which, though raised up, are in all cases *regularly* stratified. It follows that the disturbance in the position of the most recent strata has not extended very deep down, and that, as the ideal section given below shows, a distortion of the surface strata took place without extending to the rock lying below.

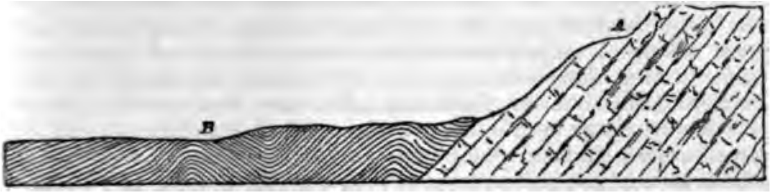

Fig. 19.—Ideal section showing the disturbances in the position of the Tertiary strata on Spitzbergen.

***A.* Older strata, belonging to the Mountain Limestone or Hecla Hook formation.**
***B.* Tertiary strata.**

Under such circumstances it is clearly impossible that the distortion was occasioned by plutonic forces in the interior of the earth. I have before maintained that such disturbances can easily be explained by the action of repeated inconsiderable changes in the temperature of the strata, and their expansion and contraction thereby occasioned. For if a stratum alternately contracts and expands through change of temperature, it is natural that during the contraction, as soon as it passes the limit of elasticity, cracks must arise. These cracks generally close again, when the strata expand, but this is not unfrequently prevented by the formation of inconsiderable chemical or mechanical deposits in the open crack, and in this case a dislocation of the strata must take place, which on changes of temperature following is repeated again and again, and thus gradually bringing about very considerable changes in the original horizontal position of the strata. A clear representation of the alterations which in this way may take place under favourable circumstances during a single winter is afforded by the hummock walls and packs of the polar ice, which are clearly formed in this way, that the originally level ice-field alternately contracts with cold, whereby cracks arise, which, however, within a few hours freeze together again, and expands in mild weather, whereby a dislocation must naturally take place.

Such great changes of temperature as occur upon an ice-field exposed to the unceasing oscillations of temperature of the atmosphere, do not naturally take place in a solid earthy layer, and the cracks which arise in the latter are perhaps not so completely filled again as those in an ice-field; but on the other hand the action takes place during far longer periods of time extending even to hundreds and thousands of years.

In consequence of the great expansion coefficient of ice, these changes must be further accelerated if the porous earthy layer has been completely soaked with water, which is then frozen, and in that case the cracks caused by the contraction of the mass are speedily filled with new ice. It is therefore only what we might expect, to find the Tertiary sandy and clayey strata, which have been thus acted on by water and ice, more dislocated and contorted than the older rocks lying at a depth, which the yearly changes of temperature scarcely reach in a sensible degree.

X. *Post-Miocene and Quaternary strata.*—All the fossils found in the foregoing strata show that Spitzbergen, during former geological ages, enjoyed a magnificent climate, which indeed was somewhat colder during the Miocene period, but was still favourable for an extraordinarily abundant vegetation, much more luxuriant than that which now occurs even in the southern part of Scandinavia; and I have in these strata sought in vain for any sign that, as some geologists have of late endeavoured to render probable, these favourable climatic conditions have been broken off by intervals of ancient glacial periods. The profiles I have had the opportunity to examine during my various Spitzbergen expeditions would certainly, if laid down in a line, occupy an extent of *a thousand English miles;* and if any former glacial period had existed in this region, there ought to have been some trace to be observed of erratic blocks or other formations which distinguish glacial action. But this has not been the case. In the strata, whose length I have reckoned above, I have not found a single fragment of a foreign rock so large as a child's head.[1] The round nodules in the Triassic and Jurassic strata are clearly concretionary formations, which contain the same fossils as the surrounding strata.

It would be of great importance to discover strata which would give us an idea of the passage from the Miocene period, with its Taxodium, beech and plane forests, to the mer de glace of the present period. I have not succeeded in doing that; but I am persuaded that by future complete examination of the peninsula which separates Ice from Bell Sound, we may gain data for answering the interesting questions relating to this point.

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[1] The only certain sign of glacial formations, perhaps, is a block of considerable size, which has been transported some distance from its original position.

In the deep ravines formed by streams, which in North-west Greenland cut through first the sand beds formed during the glacial period, lower down the Miocene, not glacial sand beds, we have an excellent opportunity of seeing the difference between them, which is very noticeable, inasmuch as erratic blocks are never absent in the former, but always in the latter. On the other hand, I am convinced that sharp-cornered stones, or stone fragments inclosed in considerable quantity in a bed of sand or clay (so-called Krosstensgrus), by no means afford certain evidence that it is of glacial origin. In this case the mistake is fallen into, as in so many other geological questions, by concluding, because on one occasion a cause A produced an effect B, that the effect B is always produced by the cause A. Gravel with sharp-cornered stone fragments is found, at least in the countries where frost tends to break up the rock surface, always at the foot of steep mountain sides clear of vegetation, and on Spitzbergen also on the flats, which in many places surround the foot of a mountain, extensive tracts, where the ground consists of such a gravel-bed formed by frost, which is increased by every spring flood, and then, being drenched with water, is exceedingly difficult to cross, and very destructive for the shoes. If I except a breccia, belonging to the Hecla Hook formation, which is found in many places, for example at the mouth of Bell Sound, there does not occur in the sedimentary strata of Spitzbergen or elsewhere any appearance of old Moraine gravel-beds.

Before concluding this account of the Geology of these regions, I wish to notice the strata which are believed to show that Spitzbergen, during a not very remote period of time, of which Geology gives evidence, enjoyed a climate better than the present. At various places on Spitzbergen, at the bottom of Lomme Bay, at Cape Thordsen, in Blomstrand's strata at Advent Bay, there are found large and well-developed shells of a bivalve *Mytilus edulis*, which is not now found living on the coasts of Spitzbergen, though on the west coast of Scandinavia it everywhere covers the rocks near the sea-shore. These shells occur most plentifully in the bed of a river which runs through Reindeer Valley at Cape Thordsen. They are probably washed out of a thin bed of sand at a height of about 20 or 30 feet above the present sea-level, which is intersected by the river. The geological age of this bed cannot be very great, and it has clearly been formed since the present basin of Ice Sound, or at least the greater part of it has been hollowed out by glacial action.[1]

XI. *Recent formations.*—Glaciers and loose earthy layers formed by glaciers.

The interesting circumstances connected with these formations deserve their own chapter, the more so as they have a peculiar bearing upon the explication of the loose layers in Sweden. But from want of time, at present, I must defer this till another occasion.

VI.—ON THE DISCOVERY OF *PALÆACIS CUNEATA*, MEEK & WORTHEN, IN CARBONIFEROUS LIMESTONE NEAR HENBURY, BRISTOL.

By S. G. PERCEVAL, Esq.

THE above form I found a year or two ago in the Encrinital Limestone forming the upper bed of the Lower Limestone Shales which occur on the south side of Combe Down (overlooking Combe House), near its western extremity. I have also traced it in an outcrop of the same limestone in the plantation on the north side of Kingsweston Down, near its western extremity. At both these localities the fossil is associated with *Zaphrentis Phillipsi*, a small coral which is characteristic of the bed. *Palæacis* probably also occurs in the corresponding beds exposed in the Avon section, and elsewhere; but though tolerably abundant, is not likely to be observed, on account of its small size, except where the rock is well weathered. The accompanying are sketches of two specimens from Combe

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[1] Compare: Miocene Flora und Fauna Spitsbergens, p. 23. With reference to the vegetable remains from these strata described by Heer, it may here be stated, that since Heer's work was published, *Betula nana* has been found growing on the north-east shore of Coal Bay.

Down which much resemble those figured in the Geol. Report of Illinois (Meek and Worthen), vol. ii. p. 262, plate 19, fig. 1 *a*, *b*, *c*.

Palæacis cuneata, Meek & Worthen;
Carboniferous Limestone, near Henbury, Bristol.

Mr. Robert Etheridge, jun., F.G.S., has kindly favoured me with the following remarks on some specimens forwarded to him.

"Your fossil appears to be the *Palæacis cuneata* described by Meek & Worthen in the Proceedings of the Academy of Natural Sciences of Philadelphia (1860, p. 448), and is there referred and in their Geological Report (vol. ii. p. 262, pl. 19, fig. 1 *a–d*) to the *Petrospongidæ*, under the name of *Sphenopoterium*. Meek & Worthen at first regarded it as a coral, believing the striæ seen within the cells to be septa, but placed the genus amongst the sponges on the authority of Prof. A. E. Verrill, of Yale College, who considered that such might perhaps be the affinity of the American fossil.

"Prof. de Koninck refers[1] the various species of *Sphenopoterium* to the genus *Palæacis* of Jules Haime, which appears to have a slight precedence over Meek & Worthen's name.

"Prof. de Koninck states that M. von Seebach first pointed out the identity of *Sphenopoterium* and *Palæacis*,[2] and that it was a true perforate coral of the section Madreporidæ of Edwards & Haime.

"The American specimens are from the St. Louis Group of the Lower Carboniferous series; locality, *Spurgen* Hill, Indiana. The specimen agrees generally with the specific characters assigned to *P. cuneata*, viz. compressed, cuneate, longer than wide; calices from two to five, deep, with an oval aperture and directed obliquely outwards and upwards, with crenulate vermicular striæ, covering the whole of the external surface.

"Prof. de Koninck appears to consider *P.* (*Sphenopoterium*) *cuneata*, M. & W., as identical with *P. cuneiformis*, J. Haime, which is perhaps the more correct name for the fossil, although I am not acquainted with the description of the latter.

"I have not before heard of the discovery of *Palæacis* in this country."

VII.—NOTE ON THE OCCURRENCE OF PHOSPHATISED CARBONATE OF LIME AT CAVE HA, YORKSHIRE.

By J. E. MARR, St. John's College, Cambridge.

IT may be worth while to record the occurrence of phosphatised carbonate of lime in Cave Ha, near Giggleswick, which has been explored by Prof. Hughes (see Journal of the Anthropological

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[1] In his *Nouvelles Recherches sur les Animaux Fossiles du Terrain Carbonifère de la Belgique*, p. 154.

[2] *Nachrichten der Königlichen Gesellschafft der Wissenschaften zu Göttingen*, 1866, p. 255.

Institute for December, 1873, vol. iii.). The phosphatised material, which forms stalagmitic layers at the side of and interstratified with the other deposits, is leaden-grey in colour, weathering light brown outside, friable, and full of small holes. Portions of it yielded, on analysis, a large per-centage of phosphate of lime.

It is not probable that these deposits were thrown down in a phosphatised condition, as they occur also unphosphatised.

The beds in which they are found were in places largely made up of the bones of small birds, mammals, etc., which, as Prof. Hughes has shown, are chiefly the remains of the pellets of owls and kestrels; feathers and skin occurring in the upper, but none in the lower part of the deposit. The only apparent way in which it seems that the travertine could have become phosphatised is by the percolation of water through the pellet bed, until it was stopped by the stalagmite, which would slowly absorb the water, and allow time for the chemical reactions which resulted in the phosphatising of a portion of it.

A somewhat similar instance is noticed by Prof. Dana ("Coral and Coral Islands," p. 293), who states that a deposit of guano on Howland's Island has been the means of phosphatising fragments of coral which have somehow become included in its mass. Similarly at Caylus phosphatised matter occurs associated with the bones themselves; but in the case of Cave Ha no such matter occurs in the deposits in which the bones are found, but only in the travertine surrounding and associated with the bones.

NOTICES OF MEMOIRS.

I.—The Antiquity of Man, Illustrated by the Contents of Caves and the Relics of the Cave-folk. By Prof. T. Rupert Jones, F.R.S., F.G.S.[1]

PROFESSOR Rupert Jones introduced his subject by reminding his hearers that antiquaries can trace back the successive periods of governments and dynasties by the relics and ruins beneath London, from the Georgian to the Roman age. He referred to Colonel Lane Fox's discovery of an old pile-village of the Romano-British pariahs in the Finsbury marsh, and to the indications of still older aboriginal wattled huts in pit-dwellings on the gravel subsoil beneath Paul's Cross, in Cheapside. The fossil contents of this gravel, under various parts of London, lead us further back in time beyond the historic and pre-historic ages to what geologists term the "post-Tertiary period," when the Thames, much wider than now, formed great shoals of gravelly shingle, and wide-spread flats of loamy flood-mud, and drifted away the carcasses of mammoth, rhinoceros, lion, urus, musk-ox, and other animals now strange to the district. The relics of man, such as implements of stone, are found here and there, with the bones of these Pleistocene animals in the valley-gravels of the Thames and its tributaries; also in similar gravels in neighbouring valleys, both in England and France, and in the caves of limestone districts, where similar conditions existed. The subsequent decrease of the river, leaving its terraced margins of gravel and loam, and the ultimate coating of peat over the marshy flats bordering its now narrow channel, complete the history of the changes down to the historic period. In these later river-deposits, and in the peat-bogs, implements of polished stone, of bronze, and of iron, are found to have been successively deposited; but in the older gravels and associated loams, whether in the valleys or in the caves, stone implements (shaped only by chipping) are found, and, as the oldest kind, have given the name "Palæolithic" to their period; whilst the subsequent age, when man had got the habit of sharpening his weapons of stone by grinding, is termed "Neolithic." The great lapse of time required to complete the formation of the Danish peat-bogs, in which implements of iron, bronze, and polished stone are successively accompanied by the beech of the present period, the older oak, and the still more ancient fir tree, belonging to three changes of conditions, and of the associated animal life, was next dwelt upon. An account of the Swiss lake-dwellings, or pile-villages, was then given; and the indications of successive generations or peoples, using iron, bronze, and polished stone tools, in more or less distinct gradations, were pointed out. Those using implements of stone were not altogether uncivilized; and yet, if the incomplete evidence of geographical changes be accepted, they lived some 6000 years before the Roman conquest of Western Europe. They did not possess the reindeer, though that animal had been hunted near by in earlier times by cave-dwellers (Canton Schaffhausen), and in France; and then the climate must have been cold enough for its existence so far south, and cold enough for the habitation of rock-shelters on sunny slopes, where during the present summers of France, even for the stench-bearing Esquimaux to abide, with the heaps of garbage, stinking flesh and bones, would have been impossible; but there, the hunters of the reindeer, horse, and musk-ox, did live, using chipped flint tools, and knowing not how to grind and polish them—though they used some kinds of grindstones in preparing food and paint, and were artistically inclined. They cleverly engraved outlines of animals and other things on bone, ivory, and stone, with pointed flints, and shaped bone and ivory into handles of poniards and quaint statuettes. Among their drawings is a lively figure of the hairy high-fronted elephant (Mammoth), which they therefore must have seen, and which ranged over the colder regions of the western hemisphere. The long and unknown space of time requisite for the change of climate from Arctic conditions in South France and Switzerland to warmer winters and hotter summers, unfavourable to the existence of mammoth, reindeer, and musk-ox, divided the cave-dwellers, using chipped flakes, from the lake-dwellers, using polished stone implements. These cave-folk of Dordogne and elsewhere, however, were by no means the oldest inhabitants of caves. They lived at or near *the level of* existing rivers; but there are caves containing relics of human inhabitants, which have been left high up in the limestone cliffs, whilst the rivers have worn away the gorge below to a great depth (nearly 300 ft. at Gailenreuth; 75 ft. at Brixham). This is shown by the presence of certain pebbles in the deposits within the cave, which must have rolled across the interval, from the other side of the valley, whilst a floor existed at a level of the cave. If this excavation be due to the violent rush of the torrent from the increased slope of its channel, caused by the rising of the land, what was the rate of elevation? Further, some few of the caves contain stone implements of ruder make than those left in others; and the valley-gravels left behind as terraces and isolated patches by the rivers, which have deepened and narrowed their channels, also contain such rude and even ruder implements, carefully, after all, but roughly chipped, and doubtless serving very well the purpose to which these early people applied them. These gravels contain remains of the Arctic animals. Their age is to be reckoned by the time required for their formation and their distribution. The subsequent excavation of lower valleys, and the other stages of time already indicated, necessarily lengthen their chronology. Their existence is owing to the early formation of gravel-flats and plains of loam out of the débris of the land, when it was far above its present height; and when Western Europe had been raised so high out of water as to comprise the British Islands as far as the well-known "hundred-fathom-line," which when raised to the water-level would of course add at least 600 ft. to the height of the land's surface. The Alps were much higher than now; and probably Snowdon stood at least 2000 ft. higher than at present. This elevation originated in the great alteration of the earth's crust in this portion of the globe by contraction, immediately after the long "Tertiary Period" of geologists, bringing in the new conditions of geography, hydrography, and distribution of life in what is known as the "post-Tertiary Period." The great uprise of land was probably slow; it introduced enormous glaciers, grooving out great gorges, which, after vast and continuous changes, the greatest rivers have scarcely yet filled up with their plain-making detritus. Whether men existed or not in this earliest part of the Quaternary period is as yet unproved. A great reaction took place, and a great and gradual subsidence lowered plain and mountain, until Snowdon sank to be an island not more than 1000 ft. at most in height, and the shoulders of the mountain were below the great northern sea; for, when it rose again, Moel Tryfaen (now 1300 ft. above the sea) bore up the well-known sands and shingle with marine shells, in witness of the change. Man had set foot in this region by that time; for when the glaciers, during some of their oscillations, occupied the great vales of Western Yorkshire, one of them left some of the characteristic laminated mud in a cave opening against its lateral moraine, and this mud buried up some old cave-earth, in which are bones of elephant, rhinoceros, hippopotamus, hyæna, and man. This glacial clay was surmounted by a cave-earth formed after the glacier had melted away and left the valley open but cold, for reindeer bones occur in this layer. Subsequently the face of the cliff slowly shed its frost-bitten fragments, and formed a talus of great thickness, on the slope of which Neolithic men came and went. Then after some 500 years (as measured by the rate of formation of the talus), the Romano-British (or Brit-welsh), driven from their cities by invaders (Picts or Saxon), lodged in the cave, and left their relics on the sunny slope outside; and these are covered by the fallen screes of 1200 years. Add these small sums of historic and pre-historic years together; allow for the period of reindeer life in Yorkshire; measure out a time for the glacier's coming and going; and add the many years and ages whilst the great Pleistocene animals roamed over the changing scene, and some notion will be gained of the antiquity of man. To allow for the last uprise of Snowdon, for its previous subsidence, and still earlier and higher elevation, some 200,000 years at least is required, when the glacial period came in. If not before this period, certainly during some part of the time, whilst England was continuous with the Continent, the mammoth and man existed here together; and the many great changes that have occurred since Palæolithic man left his implements in lakes, rivers, and caves, have required a large proportion of those 2000 centuries.

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[1] Being the substance of a Lecture delivered to the Croydon Microscopical Club, on Wednesday evening, April 26th, 1876, in the Public Hall; Henry Lee, Esq., F.L.S., F.G.S., etc., President of the Club, in the Chair.

II.—RESULTS OF OBSERVATIONS ON THE ESKERS, LAKE-BASINS, AND POST-GLACIAL RIVER-COURSES OF CHESHIRE, SHROPSHIRE, DENBIGHSHIRE, AND FLINTSHIRE, WITH REMARKS ON THE SEQUENCE OF GLACIAL EVENTS IN THE N.W. OF ENGLAND AND WALES. By D. MACKINTOSH, F.G.S.

[Read before the Chester Society of Natural Science, Feb. 3, 1876.]

THE Chester Society of Natural Science, which was established several years ago by the late Rev. Charles Kingsley, now numbers between five and six hundred members. The above paper is the second that has been printed. In it the author begins by giving an account of the drifts between Chester, Gresford, and Wrexham, with a particular reference to the sudden change of level exhibited by the upper or brick-clay between Pulford and Gresford, a change nearly 200 feet in vertical extent. The lower Boulder-clay in this neighbourhood is either confined to patches or represented by an angular rocky rubble called "rammel." The author then goes on to describe the distribution of Eskers in Caernarvonshire, Glyn Ceiriog, upper valley of the Dee, around Gresford, Gwersyllt, Cefn-y-bedd, Padeswood, Mold, Nannerch, Caerwys, Flint, Oakmere (east side of Delamere Forest), Beeston Castle, Combermere, Baschurch, Oswestry, and especially around Ellesmere. The author then enters into a particular consideration of the causes which determined the positions of eskers, laying great stress on the influence of projecting rocks, etc. The curvilinear forms of esker knolls, and especially of the enclosed hollows, he attributes to both the depositing and denuding action of eddying tidal currents. A more detailed account is then given of the high-level eskers on Halkin mountain, which contain fragments of sea-shells, and one of hich is a *perched* esker, 950 feet above the sea-level; of "a very riking array of gigantic eskers" between Bodfari and Mold, a umber of which on or near to a watershed reach a height of tween 120 and 150 feet, and which often rise at an angle of 45°; the eskers enclosing swamp- and lake-basins near Gresford, and ound Ellesmere. The latter are often as abrupt as artificial earthorks, and rise to a height of quite 150 feet above the very beautiful d pellucid sheets of water which repose in the intermediate hollows. hese eskers and lake-basins form quite a feature on the Ordnance ap. A few of them are capped with clay. After considering the uses of the retention of water in the esker hollows (which nerally appear to consist of sand or fine gravel), and preferring e theory that "the decay of vegetation artificially planted or turally grown in the basins may have increasingly acted as a tainer of water," the author proceeds to assign reasons for rerding the forms of post-glacial river-courses "as the effect of equal deposition, tidal scour, and freshwater floods." Among ountains near the sources of drift-supply, valleys were often filled to a certain height with drift extending uniformly and conuously across; but in the greater part of the district described in e paper, the filling up of the valleys (according to the author) ust have been very partial and unequal, so that the rivers, nerally speaking, found ready-made channels after the final nergence of the land. "In many places the denudation (effected the rivers) would amount to cutting a slice out of the side of e knoll, and leaving a knoll or drift-slope on the other side of e valley unscathed, or it would take the form of a lateral encroachent on a knoll or slope, so as to leave either a straight or horseoe-shaped cliff-line, the opposite side of the valley still retaining e shape given to it by the sea." After supporting his ideas by ferring to phenomena in the courses of the Dee, Alyn, and Ceiriog, Morecambe Bay, the estuary of the Mersey, the pits in the Irish a, English Channel, etc., the author concludes with the following neral account of the north-west of England and Wales:—"I lieve this area includes a variety of phenomena which are more lculated than those of any other British area to suggest the true quence of glacial and interglacial events. Within a small compass embraces plains, wide and narrow valleys, cwms, lakes, tablends, groups and ranges of mountains, and neighbouring sea-beds. ascending order it contains, (1st) pre-glacial white clay and sand; nd) two if not three kinds of lower boulder-drift which in different stricts go under the names of *rammel* (ground moraine of Mr. ellard Reade), blue clink, pinnel or sammel, in addition to a elly lower boulder-clay; (3rd) coarse esker-gravel-and-sand of lly or adjacent districts; (4th) fine sand and gravel of low-level ains; (5th) upper boulder or brick-clay. Southward the area der consideration graduates into a non-glacial district. Northwards graduates into the Lake District, and westwards into the Snownian and Merionethshire Districts, in both of which are to be und the *sure signs* of great sheets of land-ice and glaciers—namely, groups of dome-shaped rocks or *roches moutonnées*, often crossing stratification and cleavage, showing smoothly-rounded and striated up-stream, and jagged down-stream or lee sides, and occurring at both low and high levels. In the boulder-clay of the plains the intensely glaciated stones (more so than I have seen or heard of in any other part of the British Isles) bear witness (as I have elsewhere endeavoured to show) to the action of floating ice. There are numerous and widespread indications of the transportation of boulders across mountain-ranges and drainage-areas, and to distances probably not paralleled in any other part of the British Islands. In some of the upland cwms and valleys there are perhaps the best defined *supra-glacial moraines* to be met with anywhere else in the kingdom." This is followed by a statement of the newest opinions at which the author has arrived concerning the general sequence of glacial and interglacial events.[1]

REPORTS AND PROCEEDINGS.

Geological Society of London.—I.—April 5, 1876.—Prof. P. Martin Duncan, M.B., F.R.S., President, in the Chair. The following communications were read:—

1. "The Bone-caves of Creswell Crags."—Second paper. By the Rev. J. Magens Mello, M.A., F.G.S.

In this paper the author gives an account of the continuation of his researches upon the contents of the caves in Creswell Crags, Derbyshire. The further exploration of the Pin Hole Cave described in his former paper[2] furnished a few bones of Reindeer, *Rhinoceros tichorhinus*, and other animals, but no more remains of the Arctic Fox, which were particularly sought for. Operations in this cave were stopped because the red sand in which the bones were found towards the entrance became filled with limestone fragments, and almost barren of organic remains. The author then commenced the examination of a chambered cave called Robin Hood's Cave, situated a little lower down the ravine on the same side. The section of the contents of this cave showed a small thickness of dark surface-soil, containing fragments of Roman and Mediæval pottery, a human incisor, and bones of sheep and other recent animals; over a considerable portion a hard limestone breccia, varying in thickness from a few inches to about three feet; beneath this a deposit of light-coloured cave-earth, varying in thickness inversely to the breccia, overlying a dark-red sand about three feet thick, like that of the Pin Hole, but with patches of laminated red clay near the base, and containing scattered nodules of black oxide of manganese, and some quartzite and other pebbles, which rested upon a bed of lighter-coloured sands containing blocks of limestone, probably forming part of the original floor of the cavern. The hard stalagmitic breccia contained a great many bones, chiefly of small animals, but with some of Reindeer, and teeth of *Rhinoceros tichorhinus*, Hyæna, Horse, Water Vole, and numerous flint-flakes and chips, and a few cores. Some of the flakes were of superior workmanship. A few quartzite implements were also found in the breccia. The cave-earth contained a few flint implements, but most of the human relics found in it were of quartzite, and of decidedly Palæolithic aspect. There was also an implement of clay-ironstone. The animal remains chiefly found in the cave-earth were teeth of Horse, *Rhinoceros tichorhinus*, and Hyæna, and fragments of both jaws of the last-mentioned animal. Bones and teeth of Reindeer and teeth of Cave-Lion and Bear also occurred. The red sand underlying the cave-earth contained but few bones, except in one place, where antlers and bones of Reindeer and bones of Bison and Hyæna occurred. At another part a small molar of *Elephas primigenius* was found. A large proportion of the bones had been gnawed by Hyænas, to whose agency the author ascribed the presence of most of the animal remains found; but he remarked that no coprolites of Hyænas had been met with. The following is a list of the animals whose remains occurred in this cavern:—*Felis leo* (var. *spelæa*), *Hyæna crocuta* (var. *spelæa*), *Ursus arctos*, *U. ferox*, *Canis familiaris*, *C. lupus*, *C. vulpes*, *Elephas primigenius*, *Equus caballus*, *Rhinoceros tichorhinus*, *Bos bison* (var. *priscus*), *Bos longifrons*, *Capra hircus*, *Sus scrofa*, *domesticus* and *ferox*, *Cervus megaceros*, *C. tarandus*, *Arvicola amphibius*, and *Lepus timidus*.

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[1] For Articles on Drift-deposits by Mr. Mackintosh, see Geol. Mag. for Oct. and Dec., 1870; Feb., June, and July, 1871; Jan. and Sept., 1872; Feb., 1874; etc.

[2] *See Quart.* Journ. Geol. Soc. vol. xxxi. p. 679.

2. "On the Mammalia and Traces of Man found in the Robin Hood Cave." By W. Boyd Dawkins, Esq., M.A., F.R.S., F.G.S., F.S.A., Professor of Geology and Palæontology in Owens College, Manchester.

The author noticed the various species of animals discovered by Mr. Mello during the researches, the results of which are given in the preceding paper, and drew certain conclusions from their mode of occurrence as to the history of Robin Hood's Cave. He considered that the cave was occupied by Hyænas during the formation of the lowest and middle deposits, and that the great majority of the other animals whose remains occur in the cave were dragged into it by the Hyænas. That they served as food for the latter is shown by the condition of many of the bones. During this period the red sand and clay of the lowest stratum was deposited by occasional floods. The red loam or cave-earth forming the middle stratum was probably introduced during heavy rains. The occupation of the cave by Hyænas still continued, but it was disturbed by the visits of Palæolithic hunters. The remains found in the breccia indicate that the cave was inhabited by man, and less frequently visited by Hyænas than before. The presence of vertebræ of the Hare in the breccia would imply that the hunters who occupied the cave had not the dog as a domestic animal. After a discussion of the relations of the animals forming the fauna of the cave, the author proceeded to describe the traces of man found in it, which consist of fragments of charcoal, and implements made of antler and mammoth tooth, quartzite, ironstone, greenstone, and flint. The distribution of these implements in the cave represents three distinct stages. In the cave-earth the existence of man is indicated by the quartzite implements, which are far ruder than those generally formed of the more easily fashioned flint. Out of 94 worked quartzite pebbles only three occurred in the breccia, while of 267 worked flints only eight were met with in the cave-earth. The ruder implements were thus evidently the older, corresponding in general form with those assigned by De Mortillet to "the age of Moustier and St. Acheul," represented in England by the ruder implements of the lower breccia in Kent's Hole. The newer or flint series includes some highly finished implements, such as are referred by De Mortillet to "the age of Solutré," and are found in England in the cave-earth of Kent's Hole and Wookey Hole. The discovery of these implements considerably extends the range of the Palæolithic hunters to the north and west, and at the same time establishes a direct relation in point of time between the ruder types of implements below and the more highly finished ones above.

3. "Notes on the Gravels, Sands, and other Superficial Deposits in the Neighbourhood of Newton-Abbot." By Horace B. Woodward, Esq., F.G.S.

The writer pointed out that most of the deposits termed Upper Greensand in the immediate neighbourhood of Newton-Abbot were in reality intercalated with coarse gravel-beds, containing, among others, fragments of greensand, chert, and chalk flint. He considered that the only traces of Greensand *in situ* were probably on the summit of Milber Down and east of Combe Farm, deposits which were identified by Mr. Godwin-Austen. But he could not agree in the identification of Greensand at other localities in the Bovey Valley, considering the few fossils found to have been derived, and with much other material to have been evidently due to the denudation of Chalk and Greensand. He pointed out the geographical distribution of these beds of sand and gravel, which extend from the hill-tops bordering the Bovey Valley to near the bottom of the valley, but do not descend into any outlying valleys. He likewise alluded to the peculiar dip into the valley which affects these beds in several places, and observed that sometimes they rested on the Bovey Clays and Lignites. He thought some connexion in their method of formation might be traced with somewhat similar deposits on the Haldon and Black Down Hills.

He pointed out that the "Head" at the bottom of the valley was sometimes not to be distinguished from the older gravels, from which, however, it was largely derived. He alluded to the discovery of bones, a bronze spear-head, and a wooden doll or idol in this deposit; observing that they indicated the rapid accumulation of gravel, and that this indication was one out of many that might be given, that our modern river-gravels are to a great extent made up of older gravels.

In conclusion the writer alluded to some of the deposits now forming on the margin of the Teign estuary, and which are identical [illegible]racter with the Triassic breccia.

4. "On certain Alluvial Deposits associated with the Plymouth Limestone." By R. N. Worth, Esq., F.G.S.

The author adduced certain deposits found in fissures and caverns of the Plymouth Limestone, as furnishing evidence in opposition to the views advocated by Mr. Belt in his paper on the Drifts of Devon and Cornwall.[1] The best examples occur at Plymouth Hoe, where the chief deposit fills a large "pocket" in the limestone, and consists (beneath the turf) of a bed of clayey soil, containing pebbles and small boulders, beneath which are patches of white and red clay, containing a few pebbles, and overlying a large quantity of siliceous sand. Similar, but slightly varying deposits, not unfrequently occur in association with the Limestone; and these are regarded by the author as the remains of considerable deposits which once occupied large areas in the valleys of S. Devon; and if they are not the lowland gravels of Mr. Belt, the latter are not represented in the district. The author states that there is evidence of the contemporaneity of these deposits with those of the Oreston caves; and he adds that they furnish no proof of cataclysmal action, but of orderly deposition, the bulk of the pebbles and gravels being inland nearer the source of the *débris*, and further off the sands and clays in fairly regular succession. The author further explains the presence in Cornwall of stanniferous gravels only in valleys opening to the south, by reference to the position of the watershed in that county, which has only two rivers running to the north, whilst on the south-east rivers abound.

II.—April 26, 1876.—Prof. P. Martin Duncan, M.B., F.R.S., President, in the Chair.—The following communications were read:—

1. A Translation of a Notice, by Capt. Miaulis of the Greek Royal Navy, of the Occurrence of a Submarine Crater within the Harbour of Karavossera, in the Gulf of Arta. Communicated by the Secretary of State for Foreign Affairs.

2. "The Physical History of the Dee, Wales." By Prof. A. C. Ramsay, LL.D., F.R.S., V.P.G.S.

The author stated that he regarded the valley of the Dee as mainly preglacial throughout, and sketched the physical history of the region through which it runs. The Silurian rocks were much disturbed and denuded before and during the Carboniferous period, and the Carboniferous Limestone was deposited very unconformably on the upturned edges of both Lower and Upper Silurian strata, and once spread all over the region, probably overlain by the Millstone-grit and Coal-measures, as now in the east of Denbighshire and Flintshire. The region was again disturbed and elevated during the formation of the Permian deposits, and then by subaerial denudation a great part of the Carboniferous series was removed down to the old plain of denudation of the Silurian rocks, the surface of which thus probably stood higher than it does at present, being in the midst of a broad continental area. From a consideration of the conditions of deposition of the Mesozoic and Tertiary formations the author concluded that, from the beginning of the Permian to that of the Glacial epoch, the higher ground of Wales was land well raised above the sea, except perhaps during the deposition of the Chalk, and that during all this period it was exposed to the influence of subaerial agents of denudation. He indicated the conditions of elevation of the old table-land of Carboniferous rocks, and showed that it had probably a slope towards the east and north-east to the extent of about 23 feet in a mile. The drainage of this land then flowed in an easterly and north-easterly direction along the earliest channel of the Dee, which would be at an elevation from 1300 to 1400 feet higher than the present channel.

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[1] See Quart. Journ, Geol. Soc. vol. xxxii. p. 80.

During the Glacial epoch ice-action deepened, and more or less modified the existing channel, and scooped out the basin of Bala Lake, which was not previously in existence. The general results of this investigation are as follows:—After the last important disturbance of the Pre-Permian rocks, North Wales was carved slowly and by subaerial agencies into its present mountainous form chiefly between Permian and Preglacial times. The work of the glaciers of the latter period somewhat deepened, widened, smoothed, and striated the minor outlines of the mountains and valleys, and excavated many rock-bound lake-basins, but did not effect any great changes in the contours of the country. A minor submergence of part of Britain during part of the Glacial epoch produced no important effects on the large outlines of the rocky scenery; and the effects of subaerial waste subsequent to the Glacial epoch have been comparatively small.

3. "On the Ancient Volcano of the District of Schemnitz, Hungary." By John W. Judd, Esq., F.G.S.

The old volcanos of Hungary have long been known to present some very interesting illustrations of the relations between the igneous rocks erupted at the surface and those which have consolidated at a considerable depth beneath it. The district in which these phenomena can be best studied is that of Schemnitz; but although this area has been very carefully mapped and explored by a number of able investigators, the greatest diversities of opinion still exist concerning the relations of certain of the rock-masses exposed within it.

Over an area nearly fifty miles in diameter enormous accumulations of *andesite* and *quartz-andesite* lavas and agglomerates have been erupted, these now forming a group of mountains rising from 3000 to 4000 feet above the sea-level, and culminating in a great ring of precipitous heights overlooking a depressed central area of oval form, the site of the famous mining towns of Schemnitz, Kremnitz, and Königsberg. In the midst of this depressed central area there occurs a considerable development of *rhyolitic* lavas and tuffs, and more scattered outbursts of *basalt*. From the magnificent floras associated with the various volcanic tuffs, we know that the andesitic rocks were erupted during the earlier portion of the Upper *Miocene* period and the rhyolitic towards its close, while the basalts [illegible] *probably* of as late date as the Pliocene.

Besides the rhyolites and basalts, however, there are certain other rocks exposed in the central area of the Schemnitz district, the relations of which it is very difficult to understand. These consist of (1) strata of Lower Trias and Nummulitic age, through the midst of which the volcanic outbursts have evidently taken place; (2) masses of highly metamorphic rocks, including quartzites, crystalline limestones, various schists, gneiss and aplite; and (3) undoubted eruptive rocks, which have usually been called "syenite and granite," but for which the names of "diorite and quartz-diorite" would perhaps be more appropriate, inasmuch as the prevailing felspar in them is always a plagioclase variety.

By Beudant and other early writers the andesitic lavas were recognized as volcanic products of a comparatively recent geological period, while the "granite, syenite, and greenstone" were regarded as being of far more ancient date. By Von Pettko, Richthofen, and all the more recent investigators of the district, however, it has been clearly perceived that the "greenstones" are certainly, like the andesites, of Tertiary age, and hence such names as "greenstone-trachyte" and "propylite" have been applied to them. The studies of the author of the present memoir, both in the field and in the cabinet, have led him to the conclusion that the granitic, porphyritic, and lava rocks—which were formerly called "syenite," "greenstone," and "trachyte" respectively—*are all of similar composition and equivalent age,* and that they differ only in their more or less perfect state of crystallization, the result evidently of variations in the conditions under which they have consolidated. He is further led to regard the metamorphic masses around the several intrusive centres as being not, as has hitherto been maintained, of "Primary" (Devonian or Permian) age, but simply Triassic rocks affected by local or contact metamorphism.

The real structure of the great Schemnitz volcano was first recognized by Von Pettko in 1848, though this author erroneously regarded it as presenting an example of a "crater of elevation." The history of the formation and destruction of this volcano is now shown to be as follows:—After some small and scattered outbursts of rocks of acid composition towards the close of the Oligocene period, the grand eruptions of andesitic lavas of the Miocene began, through the agency of which a volcano of larger dimensions than Etna was gradually built up, by both central and lateral eruptions. In the midst of this volcano a crater of enormous dimensions was formed, doubtless by some great paroxysmal outbreak, and by the subsequent subsidence of the mountain the sea gained access to, and by denudation greatly enlarged the area of this "Caldera." Then in the central lagoon of the caldera a number of minor eruptions, first of acid and then of basic rocks, took place; and the volcano, which at this period of its history must have closely resembled the existing island of Santorin, was again upheaved from beneath the sea, and exposed to the wasting effects of subaerial denudation. The gradual decline of the volcanic forces in the district was marked, as is usually the case, by the appearance of hot and mineral springs, discharges of gas, occasional earthquakes, etc.

While affording such remarkable examples of the perfect transition between the so-called plutonic and the volcanic classes of rocks, and of the phenomena of contact metamorphism, the granitic masses of the Schemnitz district are without question truly *intrusive;* and a careful study of them lends no support whatever to the hypothesis that such rocks may be formed by the extreme metamorphism of sediments *in situ.* There is the most complete proof that in the Schemnitz district the formation of true mineral veins, containing gold, silver, and other metals, has taken place within the most recent geological periods; in some cases, indeed, at a later date than the Pliocene.

THE GEOLOGICAL SOCIETY OF STOCKHOLM.

(GEOLOGISKA FÖRENINGEN I STOCKHOLM.)

This Society, which has members also in Norway, Finland, and Denmark, was founded at the end of the year 1871. It meets once a month from November to May, and after each meeting is published one number of the journal "Geologiska Föreningens i Stockholm Förhandlingar" (Proceedings of the Geological Society of Stockholm), which has hitherto contained only original articles on geology, palæontology, mineralogy, mining, etc. The journal is to be had of Messrs. Samson and Wallin, Stockholm, at a cost of 5 Swedish crowns a year.

The volume of the journal has increased year by year. For the year 1875 it contained 354 pp. text, 15 tables, and several figures in the text.

Communications for the journal may be addressed to the Secretary of the Society, Edvard Erdmann, Geologist of the Geological Survey of Sweden, Stockholm.

I.—Meeting, January 15, 1876.—C. F. Wærn, Esq., F.R. Swed. Acad. Science, etc., in the Chair.

Prof. G. Nordenström described the geological nature of the Solstad copper-mine, in Southern Sweden, and exhibited some sections and a model of the mine.

Mr. O. Gumælius made some observations on the glacial deposits of Sweden.

II.—Meeting, February 3, 1876.—C. F. Wærn, etc., in the Chair.

Dr. Th. Nordström, on the geology of the Falun copper-mine. The ore is supposed to be the lower part of a very large, perpendicular lens, whose upper end was denuded during the glacial period. It is enclosed in quartzite, which rock is surrounded by mica-schist and hälleflinta.

Prof. A. E. Nordenskiöld exhibited and described some minerals from the Ural, among which was a diamond-like mineral, *demantoid,* which has the crystalline form of the garnet, and probably is nothing but garnet. In Ural it is improperly named krysolite.

Mr. A. E. Törnebohm read a paper by Mr. A. Sjögren: "On the Mode of Occurrence of the Taberg Iron-ore, in the Province Småland *in Sweden."* Mr. Sjögren has proved, by means of microscopical investigation, that Mount Taberg is on the whole composed of an almost homogeneous rock, which has a hitherto unknown composition of magnetic iron-ore and olivine.

Mr. A. Lindström exhibited crystals of calc-spar and quartz, found in Scania in a kaolin-like Boulder-clay.

III.—Meeting, March 2, 1876.—C. F. Wærn, etc., in the Chair.

Mr. A. E. Törnebohm spoke of the iron-ore mines of Dannemora, and exhibited rock-specimens and maps and sections of the mine. The ore occurs in parallel layers; it is enclosed in crystalline limestone, which is imbedded in "hälleflinta" and "euryte," confined by syenitic granite.

Mr. Fahlcrantz exhibited maps and sections which he had made of the same mine.

Dr. N. O. Holst gave an account of his theory of the origin of pebble-ridges (Kames, Eskers, Swed. "Åsar"). According to this theory these "åsar" had been formed in the channels which the water from the melting inland-ice has carved in and through the ice. The material has been produced from gravel and stones, which formerly were enclosed in the ice, but by the melting were swept down into the channels beneath.

Prof. Nordenskiöld exhibited and described some minerals from the Ural, among which was an extremely large and beautiful specimen of native platina.

Prof. Nordenström exhibited a model of the copper-mine at Åtvidaberg in the centre of Sweden.

IV.—Meeting, April 6, 1876.—C. F. Wærn, etc., in the Chair.

Dr. G. Linnarsson first made some remarks on the geology of Mount Omberg, in the centre of Sweden. He then referred to a marine gravel-bed deposited upon a layer of fresh-water peat on Gotland, many feet above the sea. In consequence of the last communication there arose a discussion between Messrs. Torell, Wærn, and Nordenskiöld, with special reference to the distribution of land and sea during the glacial period, and whether the Baltic and the Polar sea during this period had any connexion with each other or not. Mr. Torell thought that such a connexion was not yet proved.

Mr. E. Erdmann exhibited some specimens of fire-clay and fire-stones from Stabbarp coal-mine in Scania. A stone composed of Swedish materials had for four months been heated in a porcelain-kiln at Malmö (Sweden), together with a stone from Brieg in Schlesien, which latter has hitherto been considered at the porcelain-manufactory in Berlin as of the best quality known; by this test the Swedish stone showed no alteration, but the Brieg stone became almost totally melted down. Mr. Erdmann also described a peculiar phenomena of jointing in flint. By a single blow of the hammer on a piece of flint, some parts of the latter had splintered away; but exactly where the blow of the hammer had acted, a regular cone had been left standing. Two specimens with such cones, half an inch large, were exhibited. (See p. 288, at foot.)

Prof. A. E. Nordenskiöld next described some new discoveries of minerals at Nordmarken and Långban in the Province Wermland. Magnificent crystals of zinkblende, in tetrahedrons with one-inch edges, of magnetic iron-pyrites, etc., had been found. The Professor then made some remarks in connexion with a paper: "Om de Nordenskiöldske jœrnmasser" (On the Nordenskiöldian Iron-masses) by Kand. K. A. V. Steenstrup.

GEOLOGISKA FÖRENINGENS I STOCKHOLM FÖRHANDLINGEN.

(Proceedings of the Geological Society of Stockholm.)

Vol. III. No. 1. (Contents).—Nordenström, G. Further Account of the Solstad Copper-mine in Sweden.—Gumælius, O. Some Observations on the Glacial Deposits of Sweden.—Thorold, A. F. Is the Length of Time wanted for the Reproduction of Lake- and Bog-ores known? and if so, how large is that Time?—List of Members of the Geol. Soc. of Stockholm at the beginning of the year 1876.

Vol. III. No. 2.—Sjögren, A. On the Mode of Occurrence of the Taberg Iron-ore in the Province Småland, Sweden.—Pettersen, K. On Serpentine- and Olivine-rocks in Northern Norway.—Linnarsson, G. Geological Observations during a journey on Öland.

Vol. III. No. 3.—Lundgren, B. On the Species of Inoceramus in the Cretaceous Beds of Sweden.—Holst, N. O. On the Glacial Gravel-ridges (Åsar).—Widman, O. Contribution to the Knowledge of the Composition of Condrodite.—Engstrom, N. Analysis of so-called pale Knebelit from Dannemora. (The mineral is, according to Prof. Nordenskiöld, Pyrosmalite).—Nordenskiöld, A. E. Kupfferpecherz from Ural.

CORRESPONDENCE.

ABSENCE OF THE LLANDOVERY ROCKS IN THE LAKE DISTRICT.

SIR,—I see in his Table of Silurian Strata,[1] Mr. Hicks assumes that both the Upper and Lower Llandovery beds are represented in the Lake District. This is not the case, both the Upper and Lower Llandovery are absent in the Lake District. The lowest beds of the Upper Silurian in the Lake District are the equivalents of the Tarannon Shales (locally called Stockdale Shales), lying at the base of the Coniston Grits and Flags, which are equivalent to the Denbighshire Grits and Flags.

The Tarannon or Stockdale Shales, with which are associated the black Graptolitic mudstones, rest, with a very slight unconformity, on the Coniston Limestone series, which is not the representative of the Hirnant Limestone only (a small calcareous band near the top of the Bala Beds in North Wales), but of a much greater thickness of the Bala series. The Coniston Limestone series consists of various thicknesses of shale, limestone, and ashy sandstone. Between this series and the great subaerial volcanic series of the Lake District there is, as I have before shown,[2] a considerable break.

KENDAL, *7th April*, 1876. W. TALBOT AVELINE.

WASTE OF INSULAR LAND BY THE SEA.

SIR,—Some time ago I came across an ancient map showing, at three different periods, the size and form of the Island Helgelandt (Helgoland). Even if the map is not strictly accurate, it may, I think, be considered approximately so, and worthy of being reproduced on a smaller scale in the Geological Magazine. A full-sized copy, on a scale of 4 miles to an inch, has been deposited with the Geological Society of London.

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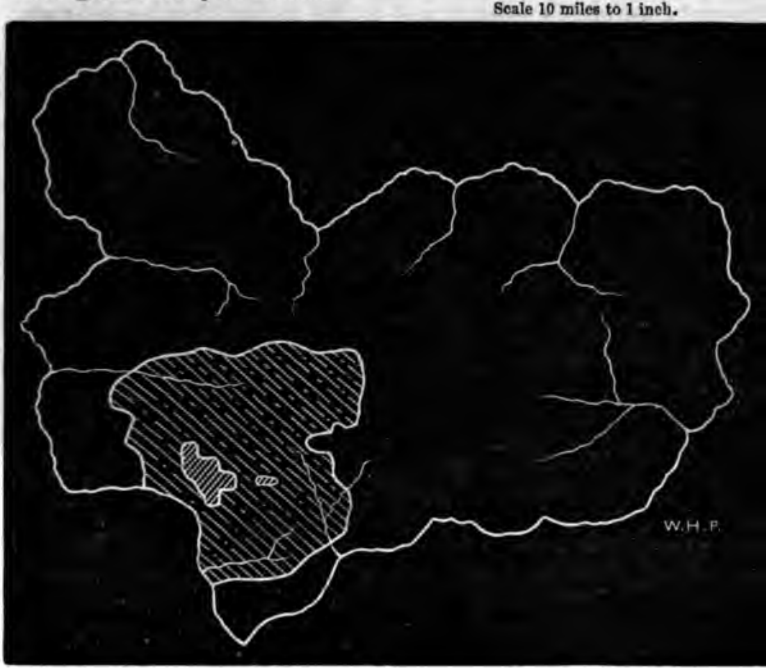
[1] GEOL. MAG. April, 1876.

[2] GEOL. MAG. Vol. IX. p. 441.



Map of Helgelandt at three different periods reduced from one said to have been "copied from an old map in the possession of the Governor of Helgelandt."

■ **A.D. 800, when 120 miles in circumference.**

■ **„ 1300, „ 45 „ „**

■ **„ 1649, Since this time it has been rapidly diminishing, the smaller Island having entirely disappeared, and the larger being considerably reduced.**

On looking at the map, one cannot fail to notice the rapidity with which the island formerly disappeared, an area of something like 500 square miles having been removed in a period of 500 years. In the following 350 years, 100 miles only were reduced, leaving an area of 4 miles, which since 1649 has diminished to a mere speck less than $\frac{1}{3}$ of a mile in superficial extent.

There are traditions that the island was suddenly reduced by incursions of the sea, but these probably are true as regards comparatively small portions only. The erosion has doubless been constant and gradual, the portion which still remains having been from some cause able the longest to resist the agencies of denudation.

and before the Middle and Upper; and a paragraph to this effect was inserted in the Introduction to the Crag Mollusca Supplement by Mr. Harmer and myself, which is published in the volume of the Palæontographical Society for 1871.

"With reference to the observation that all the great features of the country had come into existence before the Glacial period, I have already explained that several years ago I saw, and stated, that such of those great features as are connected with the curvilinear escarpments were of pre-glacial origin. What I have long contended for against the general opinion of geologists, and still contend for, is that such of these great features as are connected with the rectilinear escarpments and ridges of the south and south-east of England, as *e.g.* those of the Isles of Wight and Purbeck, and of the Portsdown and Hogsback hills, are not of pre-glacial origin; but that they originated at the close of the Glacial period, or rather at what *I call* earliest post-glacial, *i.e.* at the commencement of the emergence, as explained at page 21 of my paper in the Quarterly Journal, read Nov. 9, 1870.

"It would, I think, save much misapprehension and confusion, both now and in future, if you could manage to have this letter of explanation inserted at the end of your paper (if it is printed), and before the report of the discussion upon it. SEARLES V. WOOD, Jun.

"W. H. PENNING, Esq."

GLACIAL ORIGIN OF LAKE-BASINS.

SIR,—It appears to me that stratigraphical evidence can most successfully dispute the verdict of "not proven" brought by Mr. Judd against Prof. Ramsay's theory of the glacial origin "of certain lakes." That subsidences of the crust *can* produce rock-basins is affirmed both by historical and geological evidence; but if the basins chance to lie among strata so regular and well exposed that the fact of subsidence could not have failed to record itself, and if the outcrops on the contrary tell only of erosion, theories of subsidence are fairly out of court; and it remains only to fix on the erosive agent.

The outcrop of the Carboniferous rocks of West Northumberland is so marked and regular, that on the Ordnance one-inch map the shading is disposed in bars alternately dark and light, representing linear escarpments with their interspaces; and among these, which may be said to dip at from 6° to 12°, and are clearly pre-glacial, lie rock-basins known as the "Northumberland lakes." Obviously, if these were occasioned by localized subsidence, deviation from the average line of strike must have ensued in the beds, while concentrated erosion would leave an excavated outcrop not attended by any such change. By careful and repeated observations, I find the latter to be the case. Tracing the scarped outcrop towards the water, those on the *dipward* side of the basin are scooped back into a crescentic curve, those more central to it being obliterated altogether. No facts can be more certain than that (1) subsidence would have altered the dip *appreciably*, and that (2) it has not done so; but by simply projecting the embayed outcrops abreast of the features on either hand, the basin is filled up, and the pre-existent surface approximately restored.

I believe that these are not isolated cases of rock-basins demonstrably eroded. Semerwater, in Yorkshire, which may be considered as an outlier of the Lake District proper, is seemingly bounded by strata nearly horizontal and obviously undisturbed, and might well form a link between the small Northumberland lakes and those larger basins of the origin of which no stratigraphical evidence seems obtainable.

The comparative infrequence of sharp synclinals even in some rocks of great age seems to militate strongly against the subsidence theory of lakes. The extraordinary regularity of the Cambrian Sandstones of the western districts of Ross and Sutherland I believe to be quite irreconcilable with the great numbers of rock-basins in these regions on any theory save that of erosion. From Suilven more than 200 lakes and tarns can be counted, yet the present surface is but one of many that may have existed during the progress of that denudation of which Mr. Judd's Scottish researches so eloquently tell. If the movements in the crust had been half as rife in past geological ages as Mr. Judd's views of lake formation require for the recent one, the Cambrians could scarcely have shown a uniform dip for ten yards together.

In conclusion, rock-basins I believe may be ranged under three heads. 1. Those demonstrably due to subterranean movements. 2. Those demonstrably due to erosion. 3. A large number of which the origin is, and in some cases may always remain, doubtful.

WARK-ON-TYNE, HUGH MILLER,
May 6*th*, 1876. H.M. Geol. Survey of England and Wales.

OLDEST FOSSILIFEROUS ROCKS OF NORTHERN EUROPE.

SIR,—In a letter inserted in the May Number of the GEOLOGICAL MAGAZINE, Mr. Hicks makes some objections to my paper on the Oldest Fossiliferous Rocks of Northern Europe in the April Number. There are especially two points in which Mr. Hicks thinks that my views are incorrect and endeavours to corroborate his own.

Firstly, Mr. Hicks attempts to demonstrate that the Swedish area cannot have been depressed at as early a period as the British, by reasoning as follows: The Cambrian and Lower Silurian rocks of Sweden have an average thickness of 1000 ft., while the British are 30,000 ft. in thickness; there is no reason why the Swedish area should not have been depressed at the same rate as the British; the lowest Swedish beds must, therefore, be younger than the lowest British, for, if that be not the case, we must suppose that before the close of the Lower Silurian period the Swedish sediments were deposited in a depth of 29,000 ft. of water, which is impossible, as the characters of the faunas indicate very similar conditions in the British and Swedish areas. If we draw the full logical consequences of this Mr. Hicks' reasoning, we come of necessity to the conclusion that all the strata which we have in Sweden been used to refer issued in full,[1] and in which he regarded the marbles as metamorphic Lower Lias, and the "Calcare rosso" as the representative of the *diphyakalk* of the Venetian Alps (Upper Oolitic).

In 1846 M. Coquand, using the Ammonite red bed as a datum-line, was the first to recognize rocks of Triassic age in Tuscany, in the Grossetano district.[2] This drew a reply from Pilla, who maintained his views as to the equivalence of the *Calcare rosso*, although he admitted that the palæontological evidence was entirely against them, and now referred the Carrara marbles to the "Infra-Lias" and Rhætic, which he considered as the equivalents of the *Gryphæa arcuata* beds.[3]

In the meanwhile Prof. Savi enunciated very similar views, recognizing nothing below the Lias in the district. For him the *Calcare rosso* was Upper Jurassic, the Carrara marbles were metamorphosed Infra-Lias and Rhætic, and the Verrucano was placed below them, but as also belonging to the Liassic series.[4]

Again, in 1851, as an Appendix to their translation of Murchison's memoir "On the Geological Structure of the Alps, Apennines, and Carpathians," Savi and Meneghini adopted the same classification, with slight variations, however, such as making the upper part only of the *Calcare rosso* belong to the Upper Oolite, the lower being relegated to the Upper Lias, the statuary marbles of the Apuan Alps, Carrara, Campiglia, etc., being still looked upon as Lower Lias.

Cocchi followed in the same line, but placed the whole of the red Ammonite bed in the Lias.[5]

It should be mentioned that from 1850, when rocks of undoubted Coal-Measure age were accidentally discovered in the province of Florence, the existence of Carboniferous rocks in Tuscany had no longer been denied by any of the above-mentioned authors.

In Prof. Savi's geological map of the province of Pisa a further advance was made, for the *Calcare rosso* is there coloured as forming the upper part of the "Infra-Lias.[6] In this map the Trias is suppressed altogether.

In the same year, 1862, Capellini was able to prove the presence of indisputable "Infra-Lias" and Rhætic beds *below* the *Calcare rosso* in the Gulf of Spezia.[7] He therefore referred the Ammonite bed to the top of the Lower Lias, and placed the saccharoidal marbles of Carrara at the base of the Verrucano.

Soon after, the true order of things was made clearer still by Cocchi, who placed the statuary marbles as Lower Carboniferous.[8]

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[1] "Saggio comparativo dei terreni che componzono il suolo d'Italia," Ann. Univ. Tosc. Sci. Cosm. Pisa, t. i. p. 205 (1846).

[2] "Sur un gisement de gypse au promontoire Argentaire," Bull. Soc. Géol. France, 2e sér. t. iii. p. 302 (1845–46).

[3] "Sur le calcaire rouge ammonitifère de l'Italie," Bull. Soc. Géol. France, 2e sér. t. iv. p. 1062 (1846–47).

[4] "Sulla costituzione geologica dei Monti Pisani," 1846.

[5] "Description des roches ignées et sédimentaires de la Toscane," Bull. Soc. Géol. France, 2e sér. t. xiii. p. 226 (1855–1856).

[6] "Sopra i depositi di sal gemma e sulle acque salifere del Volterrano," Ann. Univ. Tosc. Sci. Cosm. Pisa, t. vii. p. 27 (1862).

[7] "Studi stratigrafici e paleontologici sull' Infralias nelle montagne del Golfo della Spezia," Mem. Accad. Bologna, t. i. p. 247.

[8] "Sulla Geologia dell' Italia centrale," 1864.

The discovery of fossils of Carboniferous age in connexion with the statuary marbles and their associated beds has now placed this beyond doubt, although some minor points remain to be decided.

The following classification of the Carboniferous rocks of Central Italy, therefore, may be looked upon as the true one, and in giving it M. Coquand very properly remarks that it is simply an exposition, with the added details which time and repeated investigations have brought together, of the views which he gave to the world in 1845.

A. *Permian.*—The whole of the beds known as Verrucano.

B. *Carboniferous.*

1. Coal-measure shale: Monte Jano.
2. Shale with *Spirifer glaber*: Monte Jano.
3. Saccharoidal limestones; statuary marbles; bardigli; dolomites; cippolino (micaceous limestone): Apuan Alps, Campigliese, Gerfalco, Cetona, Elba.

C. *Silurian or Devonian.*—Quartzites and slates of the Veza Valley (Apuan Alps).

The fossils of these Carboniferous divisions known in this region are the following:

Of the Coal-measures:

Neuropteris rotundifolia, Brong.: Jano.
Odontopteris Schlotheimi, Brong.: do.
Pecopteris arborescens, Brong.: do.
P. acuta, Brong.: do.
P. cyathea, Brong.: Jano.
P. Bucklandi, Brong.: do.
Annularia longifolia, Brong.: do.
Cyclopteris orbicularis, Brong.: do.

Of the Carboniferous Limestone series (Statuary and Bardigli marbles):

Loxonema, sp.: Campiglia.
Pholadomya regularis, d'Orb.: Jano.
Ph. plicata, d'Orb.: do.
Cardinia tellinaria, de Kon.: do.
Cardiomorpha pristina: do.
Leptæna arachnoïdea, d'Orb.: Jano.
Spirifer glaber, Sow.: do.
Cyathocrinus quadrangularis, Miller: do.
Ceriopora irregularis, d'Orb.: do.
Astræa, sp.: Carrara.

It may be noted that instead of Savi's supposed mass of metamorphic Cretaceous rocks, we have represented in the region of Tuscany all the geological stages, from the Inferior Oolite to crystalline schists, probably of pre-Silurian age, lying upon still older granite. The *Calcare rosso*, which throughout the investigation of these rocks has been of the highest importance, as giving first a palæontological basis of operations, returns to the place which its fossils gave it when first found in 1845, namely, to the Middle Lias. The various vicissitudes which this horizon and that of the statuary marbles have suffered during the last half century may be summed up as follows:

The *Calcare rosso ammonitifero* has in turn been referred to the following geological stages:

1. Middle Lias. 1843, Coquand.
2. Oolite (without further specialization). 1843, Savi.
3. *Terebratula diphya* zone (Diphyakalk). 1845 and 1847, Pilla; 1846, de Vecchi.
4. Upper Jurassic. 1846, Savi.
5. Partly Upper Oolite and partly Upper Lias. 1851, Savi and Meneghini; 1856, Cocchi.
6. Top of Infra Lias. 1862, Savi.
7. Top of Lower Lias. 1862, Capellini; 1864, Cocchi.
8. Lias (without further specialization). 1865, Meneghini.
9. Middle Lias. 1875, Coquand. Generally admitted.

The Statuary Marbles have in turn been referred to the—

1. Eruptive series. 1829, Savi.
2. Cretaceous. 1833, Savi.
3. Oolite (without further specialization). 1843, Savi.
4. Palæozoic, probably Carboniferous. 1845, Coquand.
5. Jurassic and Liassic. 1845, Pilla.
6. Infra-Lias and Rhætic. 1847, Pilla.
7. Lower Lias. 1851, Savi and Meneghini; 1856, Cocchi; 1862, Savi.
8. Base of Verrucano (Trias or Permian). 1862, Capellini.
9. Lower Carboniferous. 1864, Cocchi; 1875, Coquand. Generally admitted.

Let us hope that these ill-treated beds have now found a permanent rest. Still it is painful to see how long it has taken for the truth to prevail in this case. Had not the unlooked-for discovery of fossiliferous Carboniferous beds taken place, the very clear stratigraphical evidence adduced by Coquand in 1845, strengthened by his determination of Triassic beds at Spezia, would have gone for nought against the preconceived theories of high authority.

Curiously enough, at about the same time that all doubts were cleared regarding the beds of the Apuan Alps, an exactly similar proof positive was forthcoming as to the real age of a range of saccharoidal limestones at St. Béat, in the Pyrenees. M. Leymerie, a great authority on Pyrenean geology, regarded these marbles as metamorphosed Jurassic. Indeed, they have at all times been looked upon as the French representatives of the Carrara marbles. Now that fossils of Carboniferous age have been found in the series, M. Leymerie, although forced to own them Palæozoic, refuses to admit that his adversary, Dr. Garrigou, is right in calling them Carboniferous, and prefers to refer them vaguely to a pre-Carboniferous age on the ground that at St. Béat itself, where the rock is most strongly metamorphosed, no fossils have been found, although it is proved stratigraphically to be but the continuation of a fossiliferous horizon discovered by M. Coquand again.

It is, however, by this time generally accepted by all conversant with French geology, that the St. Béat marbles have now been proved to be equivalent to the statuary marbles of Carrara, and to be, like them, of Carboniferous Limestone age.[1]

II.—Distant Transport of Volcanic Dust.[2]

By Prof. A. E. Nordenskiöld,

Foreign Correspondent of the Geological Society, London.

(Translated by Alex. Leslie, Esq., Aberdeen.)

JUST a year ago the Academy received information that the day before there had fallen at Haga (a royal residence in the neighbourhood of Stockholm) rain mixed with snow, which brought down with it such a quantity of impurities that all the windows of the plant-house and the hot-beds there were covered with a fine grey ash-like dust.

[1] For Messrs. Garrigou and Leymerie's spirited controversy, see Comptes Rendus, t. lxxviii. p. 1629, t. lxxix. pp. 53, 145, and 328.

[2] *Discourse at the Annual Festival of the Swedish Academy of Sciences, 1876.*

Some of the dust was collected and examined under the microscope, and found to consist for the greater part of small, translucent (or transparent), angular, uncoloured, glass-like particles, which formed elongated filaments, bent sabre-fashion, or sharp-cornered flat bodies, partly plain, partly connected together in the form of Y or T. The filaments are commonly full of cavities, or pierced in the direction of their length by hollow canals, whereby they are often light enough to be able to float on water. On being examined in polarised light, most of the grains of dust are found to be isotropic—that is, without action on the polarisation plane of the light passing through them. Only exceptionally can there be discovered under the microscope doubly refracting crystalline particles, presumably of augite or felspar, and non-transparent black grains of magnetic iron-ore, that may be drawn out with the magnet. No traces of metallic particles could be discovered in the dust by trituration in an agate mortar and washing, nor did chemical reagents show the presence of cobalt or nickel.

It was clearly ascertained by the examination that the Haga dust is neither a common gravel or sand dust carried by the wind from neighbouring tracts, nor such a dust as that which, according to a former communication made by me at a preceding anniversary, falls down from the upper regions of space to the surface of the earth. All showed, on the contrary, that here we had to deal with a so-called volcanic ash-rain, a very common occurrence in volcanic regions, but which on this occasion was remarkable on account of the remoteness of our country from volcanos now in action.

In order to have an opportunity of studying more closely this natural phenomenon, a short account of it was published in the newspapers, with a request that the observations which might possibly have been made in regard to it in other parts of the country might be sent to the Academy of Sciences. It now appeared that the ash-rain observed at Haga had extended over a very wide region.

Thus, in Stockholm two persons, who on the 30th March between 11 A.M. and 2 P.M. had been out of doors in the neighbourhood of Gustaf Adolf's Square, had observed on their return home that their face and clothes were covered with a yellowish-grey dust, which could not be common dust, because the ground was wet and dirty, and occasionally a little snow and rain fell from a half-clear sky. The phenomenon was so striking that an account of it was given at a newspaper office, where, however, it was not taken notice of, it being asserted that the dust had come from some of the buildings under erection in the neighbourhood. Another person observed, when he crossed Ladugårdsland's Square the same day at 5 o'clock P.M., that a grey, ash-like dust fell, though in rather limited quantity, yet so that his coat became grey from it; a lady, who between a quarter past 1 and a quarter to 4 walked between Regeringsgatan and Appelbergsgatan, found on coming home her dress covered with an ash-grey powder; a gardener at Kungsholmen unexpectedly found the glass of his hot-bed frames so closely covered with a grey dust that they scarcely admitted any light. Other persons made the same observation with reference to the gas lamps at the New Bridge; at a bathing establishment in the south part of the city, where 100 cubic inches of dust were reckoned to have fallen on a roof surface of 600 square feet; in the region of Bergsund, etc.

Similar accounts, often accompanied by samples of dust, soon arrived from places situated at a greater distance from Stockholm; from Charlottendal in Brännkyrka, Fågelsta near Tumba, Södertelge, Örbyhus, Öregrund, Margretelund, Rånäs in Fasterna parish; from Svartsjö, where the ash-rain fell between 12 o'clock noon and 3 P.M.; from Vanda and Vallentuna parishes in Roslogen, where the dust fell with a hard westerly or north-westerly wind and rain mixed with snow, which began at 11 o'clock A.M.; from Söderhamn, where, according to numerous accounts, ashes fell partly dry, partly accompanied by sleet, both from 8 to 9 o'clock A.M. and at 5 P.M.; from Falun, where the ash-rain occurred at 8 o'clock A.M., without being accompanied by any other rainfall; from the neighbourhood of Tennäs Church village and other places in Härjeådalen, where the snow became grey from a fall of ashes or sand, yet in spots and very unequally, so that the snow at certain places remained quite clean, while at others when melted it yielded up to six cubic inches of ashes per square fathom; from Lekvattnets parish in Vermland; whence a distinct statement was obtained that the fallen ashes were very unequally distributed, and were collected like a shadow on the lee-side of raised objects, whence accounts were also received that a similar ash-rain had happened in the same region between the 9th and 11th of April; from Sollefteå, where a dark grey dust covered the snowfield on the morning of the 31st, after an abundant rain, mixed with snow, had fallen the preceding night.

Yet more abundant was the ash-rain in Norway. Thus some persons in Tryssild, near the frontier, remarked, when they were out between 11 and 12 o'clock in the night before the third day of Easter, that a dust fell which caused an unaccountable pain in the eyes. In the darkness they at first took it for snow, but with light it appeared to consist of fine sand. Higher up in the fjells, whose common snow covering was now in many places concealed by a grey coating of ashes, the sand was often conglomerated into large grains, which, however, speedily fell asunder in water. Thin flakes of a grey or black colour matted together, and strongly resembling the remains of burnt paper, also occurred. On the ice of a lake there even lay in many places heaps of dust weighing a sixth of a pound, but it is uncertain whether these were already collected in the air, or if they were afterwards swept together by the wind. Another correspondent remarks that the fall of ashes took place over a very extensive region, at some places accompanied by snow, at others unmixed, between 1 and 4 o'clock A.M., the temperature of the air being 12·5 C., and the wind light and its direction doubtful. At Nolden, near Sunderön, on the west coast of Norway, the surface of the snow, which the day before was clean, was seen on the morning of the 30th to be covered with a brownish-grey dust, yet the snow-fields on the highest fjell-tops were pretty clean or only covered with ashes in spots; in the neighbouring Justedalen a fine dust, though in small quantity, had fallen during a whole week, the greatest quantity on the night before the 30th, and at Ålesund 17 grammes of ashes had been collected on a square metre.

In the neighbourhood of Torghatten, the ashes which fell the 29th March and the preceding twenty-four hours would form a bed three lines thick, and here it is even said that the clouds of ashes darkened the day, and made the night uncommonly dark.

Similar accounts are given in Numedalen and Romsdalen, in Trondhjem, at Lofoden, etc. The ash-rain of the 29th and 30th March did not extend to the most northerly part of Norway, while on the other hand the snow and ice at Ramsfjord, near Tromsö, was found on the 14th March to be strewn over with a dark layer of dust. The southern boundary of the territory of the fall in question is thought to have lain north of Gothenburg, where the owner of extensive carefully kept greenhouses caused special inquiries to be made whether anything unusual had been seen upon the glass, and when he obtained a negative answer, further collected similar information from the surrounding region with the same result. Also from Husquarna, near Jönköping, Åmot, Kongsvinger, and Åbo, distinct statements were received that at these places no noticeable fall of ashes took place. It may also be stated with considerable certainty that no fall of ashes happened in eastern Sweden during the period from November, 1874, to March, 1875, because the Assistant in Meteorology at Upsala, Hildebrandson, caused the remainder of melted snow from every more considerable snowfall during this time at Upsala to be preserved; and this remainder has been found to contain common sand, remains of organic substances, iron, and traces of cobalt, but none of the easily recognizable, porous, glass-like particles which distinguish the Haga dust.

Samples of the fallen dust have been received from most of the places mentioned above, and it has shown itself under the microscope to be of quite the same kind and the same fineness as the newly described dust from Haga, that is, it consists of a fine angular pumice dust, which is neither rounded off in the smallest degree by being rubbed together in water, nor consists of smooth round glassy particles formed directly by the cooling of lava finely distributed in the form of drops or vapour.

The volcanic ashes which have fallen in Scandinavia possibly consist of a pumice sand, which in the course of time has collected in the crater opening or in cavities and passages in the interior of the volcanos, until, on the occasion of an eruption and under the action of superheated watery vapours, a violent cleansing has taken place, and the dust which has been collected during the course of many years has been thrown high into the air, to be afterwards spread by the wind to remote countries.

But even in this case some rubbing at least ought to be observable on the projecting sharp angles of the grains, and some chemical erosion to have taken place on their smooth surfaces. We should besides have expected to find among the inorganic constituents of the dust siliceous plates of diatoms, which, as Ehrenberg showed, occur very frequently in the sand thrown out from volcanos, but are completely absent in the matter now in question.

Under the microscope the Haga dust has in many respects a striking likeness to the finest dust from a so-called "Bologna drop"[1] that has sprung asunder, that is, a drop of glass which has been cooled suddenly, and therefore, from the most inconsiderable cause, for example, a scratch with a file on its surface, falls asunder to a fine powder. Here we have possibly a hint as to the formation of this dust. On the outbreak of the volcano, an immense quantity of superheated steam and strongly compressed gases has violently escaped out of the crater's lava-sea, and brought along with it masses of its glowing contents more or less finely divided. Naturally the particles of lava, which at first are in a molten state, not only solidify suddenly, but are also cooled to a very low temperature in the upper strata of the atmosphere, and thereby obtain the property of the "Bologna drop," of springing asunder, with the least concussion or shaking, to a fine dust.

On the 30th March N.W. or W. winds prevailed in the regions where the ashes fell, and it was soon supposed that the volcanic outbreak which gave origin to the ash-rain took place on the volcanic island lying to the westward in the Atlantic—Iceland. Here the land itself appeared to wish to give a contribution to the celebration of the people's thousand year fête by means of furious salvos from a number of volcanos, partly new, partly old, for the most part situated in desert and almost inaccessible regions in the interior of the island. Our knowledge of these eruptions, however, unfortunately is not as yet founded on any scientific examination, and it is perhaps the less necessary to repeat here the interesting accounts of those grand phenomena that have appeared in the newspapers, as I expect to have an opportunity another year of returning to the subject, since the region will probably be visited next summer by a distinguished geologist, well acquainted with the natural history of Iceland. I will only mention that the eruption began in the month of December, 1874, and then continued with shorter or longer intervals from numerous craters situated in the interior of the country, partly on Dyngjufjäll, partly in the northern part of Vatnajökul, or in the region between these enormous glaciers and the great snow-clad volcano Herdabreid. The most plentiful ash-rain on Iceland itself took place in consequence of an eruption which began at the place last mentioned on the 29th March, and the ashes which fell in Scandinavia probably belong to the same point of time, in which case less than twenty-four hours was required for carrying the ashes from Iceland to Scandinavia, that is, for their passing over a distance of 200 Swedish miles, or 2000 kilometres. Geological science has recorded many accounts of the fall of volcanic ashes, where the ashes have been carried by the wind to very remote regions, among others that ashes had already been carried a couple of centuries ago from Iceland to Bergen on the west coast of

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[1] Known here as "Prince Rupert's Drops."

Norway, but no example of so extensive a spreading of volcanic ashes with the wind, as from Iceland to the east coast of Sweden, is previously known. On Iceland the ashes fell in such quantity that at some places they covered the ground to a depth of six inches and destroyed the pastures. The cloud of ashes was for several hours so close that the sunlight could not penetrate it, and lights required to be kindled in the middle of the day. The ashes must also have fallen in considerable quantity in the sea between Iceland and Norway, and on its bottom there are doubtless found places where the remains of such falls collect during centuries without any considerable mixture of foreign matter. Here must be formed thick beds of volcanic ashes, which in the course of geological ages gradually harden together, and are metamorphosed to rocks of nearly the same composition, and therefore also strongly resembling those which in molten form burst forth from the interior of the earth, and we have here doubtless the key to the extension over boundless regions of the earth of stratified so-called volcanic rocks, a circumstance to which I have already long ago drawn attention with reference to the occurrence of plutonic rocks regularly stratified in the polar regions.

III.—On the Mechanics of Glaciers.

By David Burns,
Of H.M. Geological Survey.

No. 1.

It has long appeared to me that much remains to be said on this subject. When Mr. Croll's papers on the Physical Cause of the Motion of Glaciers appeared in the *Philosophical Magazine* for March, 1869, and September, 1870, I felt that, though his theory was certainly ingenious, and his statement of it clear and masterly, these papers were far from affording a satisfactory solution of the problem of which they treated. I waited, fully expecting that Mr. Croll would supplement and modify his theory, but he has not done so to my knowledge. Geologists in general seem to be as satisfied with it as he is himself, and on all hands they appeal to it as supporting them, whenever they treat of glacial phenomena, even when, if true, it shows their theories to be vain. A rather conspicuous instance of this occurs in the Geol. Mag. for October of last year, in an interesting paper by Mr. Goodchild on Coums. In that paper Mr. Goodchild commends "a proper appreciation of Mr. Croll's theory"; but I am persuaded that a proper understanding of it would have caused him either to renounce that theory or his own on the origin of Coums. I have thought it time, therefore, to place on these pages my criticisms and difficulties for the consideration of geologists, even if, as is unfortunately too likely, I have little new to advance.

Let us now turn to Mr. Croll's first paper on the Motion of Glaciers. And first let us trace the molecular melting, which is indeed the whole theory. He supposes that a molecule A at the bottom of the glacier melts and moves a bit downwards. It then freezes, and in doing so gives out the heat which melted it. The heat thus liberated now melts the next molecule in a line up the length of the glacier from A, and this molecule, in the form of water, and denominated B, trickles down to A and freezes. The heat is again liberated, and again it melts a molecule up-hill, which behaves as did the others; and so on for any distance. In this way a whole line of molecules move a short distance down-hill, and by a repetition of such movements among all its molecules does a glacier make progress.

Now it seems strange that molecule A should, on freezing, give its heat to B, from which it is some distance removed, and should impart none to the molecule on which it rests, or to those on either side. This is difficulty number one. But, supposing the molecules to be perfectly accommodating in this respect, their downward progress is only helped by heat passing along the glacier from its lower end upwards. Let us take the molecules A, B and C somewhere within or on the surface of the glacier. Supposing now B is melted by the rays of the sun. When a solid, it was in contact with both A and C, and therefore on melting it cannot move. True, when liquid, it is reduced about one-tenth in size, and in consequence its centre may move a small fraction of its diameter towards A; but on freezing again it must resume its original position. A or C now gets the heat, melts, oscillates, and freezes in its old position; and so on. From such heat there is plainly no molecular displacement.

If Mr. Croll would make his theory a little more subtle, and represent as synchronous the freezing of B and the melting of A, he would get some good of the sun's heat. For B, on melting, would get as near A as possible, and as it swelled in freezing, A would contract in melting, and hence B would remain in its new position. Thus viewed, my difficulty number one disappears, for liquid B would come down with an impact on A, and hence would more readily melt A than any other molecule. This new reading of Mr. Croll's theory has occurred to me since I started to write, and has disposed me much more favourably to it. I can now see how the sun's heat may keep down the glacier without getting in at the end and travelling up it. This was my difficulty number two. It must be borne in mind, however, that the distance the molecules can move at a time in this way is the smallest imaginable.

When I get to the paragraph on "Crevasses," I meet with more difficulties. He says: "Suppose a change of inclination from, say, 4° to 8° in the bed of the glacier. The molecules on the slope of 8° will descend more rapidly than those above on the slope of 4°. A state of tension will therefore be induced at the point where the change of inclination occurs. The ice on the slope of 8° will tend to pull after it the mass of the glacier moving more slowly on the slope above. The pull being continued, the glacier will snap asunder the moment that the cohesion of the ice is overcome." To me this "explanation" is not quite "satisfactory." How does Mr. Croll know that molecules will descend more rapidly on a slope of

8° than on one of 4°? What proof is there that these lines of molecular melting (if there be such at all) are parallel to the bed of the glacier? And even if they do vary to a degree with the bed of the glacier, it seems to me very confident theorizing to calculate on such nice action of a weak force like gravity on such a small body and through such a minute distance. Will heat travel down a slab of ice at 32° faster if held at an angle of 8° than if held at one of 4°? It follows from Mr. Croll's reasoning that such is the case, and it may be so, but he is a bold man who would assert it without experimental proof. But granting that the molecules move faster down the 8° slope, I still fail to see that a crevasse would be formed. What causes the pulling that produces the tension? A molecule that moves a little on and becomes ice again cannot pull more than it did before. Certainly each molecule on the 8° slope pulls more than on the 4° slope, but that has no connexion with Mr. Croll's theory, nor is it to that he refers. It is the faster motion of the molecules that somehow does the pulling, but in what way lies beyond my comprehension. To see what would actually happen, let us think of the glacier as constituted of molecules stretching in lines along its length. Let us suppose that some of these rows melt, and some do not, so that the melting molecules move among the others as through tubes. Suppose the end of the glacier to be at the foot of the 8° slope, and that the 4° slope is the next above. Suppose further that a molecule on the 8° slope can melt, move and freeze again in half the time that one can on the 4° slope. Concentrate attention now on one of these tubes, and let heat be applied to the end of the glacier, so that molecule A melts and moves down a little. B, C and the whole row now do likewise, and when a molecule an inch distant from A is melting, suppose A to melt again, and to continue to do so at regular intervals. This would produce in time a melting phase at intervals of an inch all the way up the 8° slope. When these phases get on to the 4° slope, they will move at half the speed, and the result will be that they will crowd on each other, and follow at intervals of half an inch. Still as many molecules move on the 4° slope as on the other, and through as great a distance. From these considerations we see that Mr. Croll does not explain the origin of crevasses, but explains how a glacier can move down a low gradient as fast as a high one, if such be the case.

If Mr. Croll, however, will adopt my amplification of his theory, he need not despair of crevasses of a kind. Given one part of a glacier exposed to the sun's rays for a sufficient time, while a higher part is protected by snow or cloud, and you will have a crevasse formed between. The lower part will flow away while the higher remains rigid and motionless. There would, however, be no fracture, but a rigid motionless glacier above and a continually decreasing one below. Altogether crevasses are difficulty number three.

I cordially agree with Mr. Croll when he claims that his theory explains why glaciers move at a greater rate in summer than in winter. I only wish it were as satisfactory in other respects. Though I cannot accept it as an explanation of the motion of glaciers in a general way, I am not prepared to discard it as having no share in the greater progress of glaciers in warm weather.

When Mr. Croll passes on to speak of the denuding power of glaciers, I am quite staggered, and realize my fourth and greatest difficulty in accepting his theory. He says: "As regards the denuding power of glaciers, I may observe that, though a glacier descends molecule by molecule, it will grind the rocky bed over which it moves as effectually as it would do did it slide down in a rigid mass in the way generally supposed; for the grinding effect is produced not by the ice of the glacier, but by the stones, sand, and other materials forced along under it. But if all the resistances opposing the descent of a glacier, internal and external, are overcome by the mere weight of the ice alone, it can be proved that in the case of one descending with a given velocity the amount of work performed in forcing the grinding materials lying under the ice forward must be as great, supposing the motion of the ice to be molecular, in the way I have explained, as it would be supposing the ice descended in the manner generally supposed."

It requires some fortitude to accuse Mr. Croll of writing nonsense on such a subject, yet, I must confess, I can make nothing else of the above. It is a mystery to me how it has been so long uncorrected by its author or unchallenged by others, as it has, so far as I am aware. There could not be a more powerfully denuding engine than a great glacier barbed with stones and propelled by gravitation or other force over the ground; nor could there be a weaker one than a great glacier, which, as a solid mass, is stationary, but on whose interior and on whose surface liquid molecules are here and there moving through infinitesimal distances. It sounds like a joke to say that "the grinding effect is produced not by the ice of the glacier, but by the stones, sand, and other materials forced along under it." Will a stone that is held in the crystalline grasp of millions of ice molecules be forced along by a few dozen water molecules trickling through a fraction of their diameter along its surface? A stone thus "forced along" may be supposed to scoop out valleys if the exigencies of geologists demand it; but the force that moves the stone would not serve to tickle the sole of a mite. I do not see how any geologist can accept this theory, and ascribe any geological effects to glaciers whatever, except the negative one of protecting the rocks where they prevail from atmospheric influences. To my thinking it were much more reasonable to ascribe the presence of the Quaker Stone in Darlington to the prevalence of Scotch mists out of the north-west, in the days when Noah was a boy, than to suppose it was lifted over the Pennine Chain by a glacier acting as described by Mr. Croll.

That gentleman's fallacy becomes, if possible, still more apparent in the concluding sentence of the paragraph I have quoted. When we regard the glacier as moving as a solid, we get the potential energy stored in the ice on the mountain top used up in doing work in grinding and polishing the rock beneath; but if we regard the glacier as moving molecule by molecule, this energy is gradually converted into heat all the way down, for each impact of a molecule against its fellow will be productive of a little.

Let us now take up Mr. Goodchild's paper on the Origin of Coums already referred to, and see how far Mr. Croll's theory assists him. Mr. Goodchild's theory, briefly stated, is this. When a tributary glacier of considerable relative size joins the main one, it thrusts the latter against the opposite bank, till they together in time wear out a curvilinear recess or Coum. Mr. Goodchild notices that this happens with streams of water, and he insists on a perfect analogy between these and glaciers. To all this I would have had no objection had he let Mr. Croll's theory alone. It is very true that that theory shows how a glacier behaves in some respects like a river and in others like a solid; but, unfortunately for Mr. Goodchild, Mr. Croll's glacier is a solid when it should be a liquid, and is a liquid when it should be a solid.

To see this clearly let us first grant that the tributary glacier exerts a great pressure against its principal. The main glacier is a great rigid crystalline mass, with a mighty shearing force, moving steadily on in its mild molecular way. Surely these characteristics are not analogous to those of a river. The water of a river is free to move in any direction, and no sooner is moving water joined by other moving water than the two together flow off in a direction and with a speed the resultant of their former directions and rates. The ice of the glacier can only move by being melted, or by having a pressure of 70 to 120 lbs. per square inch of shearing section exerted against it. It is evident that while the tiniest stream will deflect somewhat the strongest river into which it can run, the tributary glacier might as well abut against a whin-dyke as the main glacier; and that in this respect at least there is no analogy between the glaciers and the rivers.

Turning now to a consideration of the tributary glacier, it will be seen from my remarks on crevasses that I cannot accede that the tributary glacier exerts a pressure against the other, nor can I see any analogy between the action of the tributary glacier and the tributary river. The main glacier, as an object to be moved, is a stubborn solid; the tributary glacier, as a moving body, is slower and more silent than the slowest and most silent river. The motion of its molecules is that of dew, or the damp in the paper-hanging of a field-geologist's bed-room, and not the rapid and continuous motion of molecules of water in a river. The water of a river has momentum, and hence its denuding power; the ice and liquid molecules of a glacier have no momentum.

The motion of the molecules within a glacier can no more cause a thrust than the rise of the sap within a tree in the spring can pull it up by the roots.

To recapitulate briefly these conclusions: Mr. Croll's theory makes Mr. Goodchild's larger glacier a rigid stubborn thing, which can only be moved in a lateral direction by the exercise of enormous force, while it shears his smaller glacier of all its strength. To accept that theory, therefore, and to ascribe the origin of Coums to the confluence of glaciers is to perpetrate a blunder.

I wish it to be understood that I have no fault to find with Mr. Goodchild's theory as such. I have no doubt but that it is the true explanation of the phenomena in question. Indeed, I accept it as such, and regard it as a beautiful proof of the erroneous character of Mr. Croll's theory. It is certainly most creditable to Mr. Goodchild's powers of observation that he should have seen in the field the cause of these hollows, even when misled by accepted theories. It is not to be wondered at that logic should have suffered a little to effect a compromise.

The physical cause of the motion of glaciers is a problem so important and interesting, and is so far from being solved, that any suggestion or theory that pretends, or is likely, to help to a solution, should be welcomed. I have done my best to show what I consider faults in Mr. Croll's theory. I have done so because I consider it has been misleading geologists and lulling physicists to inaction by the notion getting abroad that the whole question was settled. If Mr. Croll had been as dissatisfied with his theory as I have been, and, as I trust, I have shown I have had very good reason for being, I am sure he would have returned to the subject before this to the profit of science. Nor would I have this theory too readily discarded. The motion of glaciers may be a very complex affair, and this molecular theory may yet be useful to supplement other theories so as to enable them to cover all the phenomena of glaciers.

To further the investigation as far as I can, I would here raise the consideration of a question I hinted at when speaking of "crevasses." Though surface molecules melt most frequently, it is part of Mr. Croll's theory to suppose that each and every molecule of the glacier melts many times over. Now suppose a molecule to melt somewhere in the interior of the glacier, and suppose that under it there is just room for it to move in a downward direction. The question I want to put is, would it move at all? We are dealing with very minute particles of matter, at very close quarters, and must be careful. What says the doctrine of Capillary Attraction on this point? As I write among the wilds, and have no books to refer to, I do not wish to commit myself to any direct statement on the subject at present; but, after observing the behaviour of molecules of water among molecules (or crystals rather) of sugar, it will not astonish me, supposing Mr. Croll, on returning to the subject, makes the glaciers go up-hill.

There is another consideration, which I mention the more cheerfully as it helps the molecular theory. If Mr. Croll returns to the subject, and still adheres to his theory, I am sure he will adopt my suggestion to regard the heat and molecules as moving in the same direction. Indeed, it may have been his intention to do so, but that he was unlucky in his illustration. Suppose a cubical stone somewhere in a glacier, with faces up-hill and down-hill. Further, suppose heat to be travelling down the glacier, and let us consider its effect on rows of molecules, whose lines pass through the stone normal to these faces. First, consider the molecules below the stone. Those next the stone move down-hill a little, and again a little more, but the molecules of the stone remain stationary. The consequence is that gradually a vacuum is formed against the face of the stone. Now let us consider the molecules up-hill from the stone. Heat approaches the stone, and so do molecules. The second molecule from the stone melts, and comes down against the one touching the stone, which in turn melts as the other freezes. Now this last molecule cannot freeze, for no molecule of stone will yield to it as it yielded to its fellow, and so it remains for the time being a molecule of water. Gradually a great number of molecules of water get accumulated against the face of the stone. As their heat is conducted away they will exert a great force in freezing, and this, assisted by the vacuum forming against the opposite face, will force the stone a little bit down-hill.

Another very plausible application of this theory would be to suppose that the sun's heat in this molecular way got down from the surface of the glacier to its bottom, and there disengaged molecules of water, which would feed the stream which issues from under the glacier. Such action, however, would tend to keep boulders at the bottom of glaciers, whereas it is well known that somehow or other they get to the top.

IV.—ICE AND ICE-WORK IN NEWFOUNDLAND.[1]

By JOHN MILNE, F.G.S.,

Professor of Geology in the Imperial Mining School of Tokei, Japan.

> "And now there came both mist and snow,
> And it grew wondrous cold;
> And ice, mast high, came floating by,
> As green as emerald.
>
> And through the drift the snowy cliffs
> Did send a dismal sheen;
> Nor shape of men, nor beasts we ken—
> The ice was all between.
>
> The ice was here, the ice was there,
> The ice was all around;
> It cracked and growled and roared and howled,
> Like noises in a swound."—COLERIDGE'S *Ancient Mariner.*

WE often see a certain cause at work, and then its effect;—and the effect may be and is, doubtless, in many instances, peculiar to the cause. In Switzerland glaciers are known to have rounded and converted into "hummock"-shaped forms the rocks over which they have passed; whilst the rocks which were imprisoned in the ice, and used as tools to scour the rocky bed over which they moved, have in their turn also received a definite impression.

Hummocky tracts of land like those in Switzerland are to be seen in Scotland, Newfoundland, and other countries. Mounds of debris, filled with scratched stones like those produced by a modern glacier, are to be found in many places. These and other appearances, which are peculiar to ice-action, are ascribed to it as their originators; for, whether they be of Permian or Pleistocene age, their origin would seem to be identical.

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[1] The rough MS. of this Article was placed in the Editor's hands by his friend Mr. Milne early in 1875, but, owing to pre-occupation on the part of Editor and Author, was never put in type until this month, June, 1876. The author departed in August last for Japan, and has therefore been prevented from again seeing or revising his notes. The Editor trusts that this apology will be accepted by the reader should he find that the author has omitted to notice any papers on ice as a geological agent, which may have been published since that date.—EDIT. GEOL. MAG.

By studying the effects of modern volcanic outbursts, similar paroxysms can be shown to have occurred in bygone ages,—and it is only by having a knowledge of the present, that any true knowledge of the past can be obtained.

The action of ice upon the surface of the earth has been spoken of in all our Manuals and Text-books of Geology. De la Beche, Lyell, Ramsay, Jukes, Geikie, and others, all discuss it in its various forms.

The fact that existing glaciers had once a wide extension was not however observed earlier than 1821, when M. Venetz advanced the opinion with regard to those of the Alps. In 1836 these ideas were strengthened by the observations of M. Charpentier; but it was not until the distinguished naturalist Agassiz—fresh from the same Alpine school, where so many geological truths have been demonstrated—visited Scotland in 1840, that the curious rock-markings in that country were successfully shown to be identical with those produced by the glaciers of Switzerland.

Glaciers have been regarded from many points of view, and have been studied both mathematically and physically. Their effects have been noted, and they are now universally admitted to have been great tools in the modelling if not in the actual formation of the surface configuration of the earth. They were first suggested and shown to be a means of solving the puzzles of drift, rounded rocks, strange scratchings, and boulders, and ever since take the precedence of all other ice.

Their offspring, the Icebergs, have also been studied, and their work has been duly chronicled. The manner in which they bear rocks to warmer seas, and strew them broad-cast over the bed of the ocean, and even the way in which they may have aided in modelling a rising area, has long been dwelt on; but, being less important tools in Nature's workshop than their parents the Glaciers, deservedly without such emphasis. There is, however, another form of ice, which, from its unassuming appearance, although touched on by a few, has apparently taken too low a place in the rôle of actors with which it plays. This is the Coast-ice.

My first sight of large masses of floating ice was on my arrival at St. John's, Newfoundland, in the spring of 1872. On the morning of the 16th of May, we found ourselves wrapped in a fog, through which a high bold coast was dimly visible. At length it lifted, and we saw ourselves in a cliff-bound bay, at the head of which a narrow entrance showed us a harbour filled with ice and ships. Near us floated two great icebergs, whilst the sea around was covered with smaller lumps jostling against each other as they rose and sank upon the swell. This Arctic scene is depicted as occurring at the same place, but on a grander scale, in the frontispiece of "*Frost and Fire*," by J. F. Campbell, F.G.S.

This mass, consisting of floe-ice surrounding icebergs, was travelling southwards under the influence of the cold Arctic current, which, coming from the northern regions, after coasting along by Labrador, sweeps onward past Newfoundland, to sink beneath the warmer waters of the Gulf-stream in more southern latitudes.

On the coast of Newfoundland Icebergs generally make their appearance about the 1st of January. Their approach is heralded by a number of smaller pieces. When we reflect upon the origin of these bergs, it would appear that the greater number of them ought to be disengaged from their parent mass, the glacier, in summer-time. The semifluid mass, of which the glacier is made up, creeping slowly, like a frozen river, down the valley by the aid of heat, gravity, etc., has in summer-time its pace augmented by the increment it receives at this season of the year.[1] It then pushes itself rapidly forward into the ocean, and there by the buoyancy of the water the projecting ice-mass is detached and floated off. Why, therefore, is it that the bergs are not seen off the Coast of Newfoundland at the close of summer, or at the latest in the "fall" of the year? The answer to this may be obtained from the inference of Sir Edward Belcher, and other Arctic navigators, who tell us that in very high latitudes the ice appears to be in motion much earlier than it is farther to the South. On the 20th of May the western side of Smith's Sound has been found to be quite open for navigators in a boat, whilst Barrow Strait is not navigable till late in August. The consequence of this would appear to be that whatever ice may be set free far north early in the year is detained in more southern latitudes until the fall. Another cause also operating in keeping the ice off the coast until the spring of the year may be the wind. Although icebergs, with regard to their motion, and the direction of the wind, often present curious anomalies, yet this must to a slight degree be influential on their wanderings. In the "fall" of the year the prevalent winds on the North American side of the Atlantic are generally speaking from the west, which tend to keep all bergs out at sea, and thus, to observers on the land, they would be lost sight of; but in the spring of the year the winds are more or less northerly, which would only aid the current in bringing the ice along shore. The most apparent suggestion for the detention of the ice before reaching the shores of Labrador and Newfoundland is of course the distance it has to travel; but considering the steady rate at which this is carried on in the stream which bears them, the effects of wind, and the delay in the breaking up of the Southern Arctic barrier must have the precedence.

Theoretical considerations on the Flotation of Icebergs.—The icebergs I had the opportunity of seeing daily for several weeks whilst in the neighbourhood of St. John's, although irregular in their outlines, were by no means of such varied forms as many that were seen afterwards. Several apparently very small pieces, projecting perhaps not more than a foot out of water, when approached showed themselves as considerable masses, their magnitude being hidden by their submergence. In the "offing" "islands of ice," as the bergs are here called, were to be seen moving southwards, whilst in the bay several of them were always to be seen aground. These latter, as they slowly rose and fell with the ever-varying swell caused by the wind and tide, were deranging and grinding away the beds on which they rested. The enormous power that one of these islands of ice must possess to do such work may faintly be conceived by approaching one of them in a boat, and then considering that, although there is a mountain above water, there is from seven to nine times its mass beneath the surface. The depth of water in which one of these ponderous masses of ice can ground may often be more limited than has generally been expressed. When the berg first leaves its parent the glacier, its sides may be more or less parallel to each other, and we may sometimes get a near approach to a prismatic form. In this case not only would there be about eight times the bulk of ice beneath the water as there is above, but also there will be about eight times the depth, and we might conceive, as Jukes and Geikie tell us in their "Geology" (p. 416), that if the mass rises "300 feet above the waves," we may imagine that it "has its bottom 2,400 feet below them." In the Arctic and Antarctic regions we may therefore understand the immense depths at which an iceberg can ground, and there disturb the strata. As bergs travel towards lower latitudes, as towards Newfoundland, what with the beating of the waves and the changing of temperature they of necessity lose a great deal of the regularity of character they may previously have possessed. The greatest loss appears to be upon the portion exposed to the atmosphere, but, perhaps, more noticeable "between wind and waters."

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[1] Sir James Ross, from his observations in the Antarctic Seas, infers from the greater difference between the temperatures of the sea and air in winter-time than in summer, that it is at the former season of the year that the greater number of bergs are detached.

As this waste goes on, the berg must rise, and the ratio of the height of the exposed portion to the depth of that which is hidden grows greater. The result of this is that the exposed portion becomes less and less in diameter than that which is protected beneath the surface of the water, which at last may be looked upon as a kind of foot or pedestal.

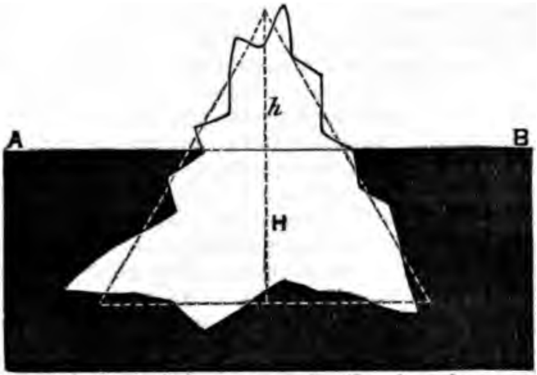
That bergs, instead of descending in parallel sides beneath the surface of the water, rather extend outwards in the form of a broad base, depends on the assumption that the disintegration is carried on at a greater rate above water than below.

Apart from these theoretical considerations, it would seem from actual observations, that although icebergs have occasionally been seen in low latitudes to ground in deep water, as mentioned by De la Beche in his "Geological Observer," where one is recorded as being stranded in 720 feet of water on the Banks of Newfoundland, the bulk of them is only to be seen upon the shoals. In fact the grounding of icebergs is used by both the fishermen of Newfoundland and Labrador as a means of finding out shallows which may be used as fishing-grounds.

If a berg is seen to ground some distance out at sea, its bearings from the land are at once observed, and it is in this way that many of the banks have been discovered.

If, instead of taking such an extreme case as the one to which I have been referring, where the generally peaked appearance of a berg, as seen above water, might be imagined as standing on a wide-spread flat base beneath the water, we consider the portion of the berg beneath the water as being a general continuation of that above, even in this case it will be seen to be very improbable that the ice extends to the great depth which is usually assigned to it.

For example, in the accompanying figure let A B be the surface of water in which we see a piece of ice floating as indicated by the black line, the general direction of that beneath the water corresponding to that which is above. Approximating to such a figure, draw on the "give-and-take" system a many-sided pyramid, or in the limiting case a cone approximately equal in volume to that of the supposed berg. This is shown by the dotted line. We have given that the position of the cone beneath the surface of the water to that which is exposed are to each other in the ratio of 8 to 1. Therefore the volume of the whole cone, which we will call V, is to that which is exposed, which we will call *v*, as 9 is to 1, *i.e.* $\frac{V}{v} = \frac{9}{1}$.



But also, as similar solids are to each other in volume as the cubes of their corresponding dimensions,

$$\frac{V}{v} = \frac{9}{1} = \frac{(h + H)^3}{h^3},$$

where *h* equals the height of the small cone of ice above water, and H equals the depth of ice below the surface,

$$\text{whence} \quad \frac{h + H}{h} = \sqrt[3]{9} = 2{\cdot}080$$

$$\therefore \quad H = \cdot h = 1{\cdot}080$$

which is equivalent to saying that in a floating cone of ice the depth below the surface of the water is but very little greater than that which is exposed above. If the ratio of $\frac{V}{v}$ had been equal to $\frac{8}{1}$, then H would *equal h, or the depth below equal that which is exposed above. That the cone would tend to* float with the apex upwards rather than downwards, may be inferred from the fact that this latter position, where the base would be upwards, would raise the centre of gravity nearer to the surface of the water, and thus bring about a condition of equilibrium not so stable as if the apex had been upwards.

These considerations, it must be borne in mind, are purely theoretical, and are only used as a means of giving a clearer idea of some of the conditions under which ice may be found floating, and especially such ice as has suffered disintegration in its wanderings.

(To be continued in our next Number.)

V.—ON SCOTTISH MONOGRAPTIDÆ.

By CHAS. LAPWORTH, F.G.S.

(PLATES IX. AND X.)

§ I.—INTRODUCTION.

1. *Succession of Silurian Rocks in the South of Scotland.*—The oldest fossiliferous strata yet detected in the Silurian district of the South of Scotland are the dark Graptolitic shales forming the well-known Moffat Series. The total thickness of this group is under 600 feet, but it is nevertheless capable of separation into three very distinct palæontological divisions, each characterized by a large proportion of peculiar fossils. The first of these divisions is of Llandeilo age, the second represents a portion of the Bala formation of North Wales, and the third, or Birkhill division, appertains, at least in part, to the epoch of the Lower Llandovery.

But the formation of the highest importance geographically is a group of comparatively unfossiliferous shales and greywackes of enormous thickness; which—reposing on the highest division of the Moffat Series in some localities, and on the middle division in others—stretches in an almost unbroken sheet from St. Abb's Head to the Mull of Galloway, and occupies at least nine-tenths of the whole Silurian area. Its rocks are thrown into innumerable folds and contortions, and the inferior strata are exposed only in long narrow bands in the lines of the deeper anticlinals. This great group appertains wholly to the Middle Silurian epoch. To its lower division belong the Girvan rocks and the so-called Gala Group of the eastern and central districts. Its highest beds are the Hawick Rocks, formerly believed to be the most ancient strata in the South of Scotland.

To the south of the Hawick Rocks, and reposing conformably upon them, lie the more fossiliferous Balmae or Riccarton beds, which are of Wenlock age, and floor a long and narrow strip of country stretching from Kirkcudbright to the central portions of the Cheviots. Strata of Ludlow age occur only in the northern areas, where they emerge from below the Upper Palæozoic rocks of Lesmahagow and the Pentland Hills.

2. *Distribution of Rhabdophora in these deposits.*—Graptolites are met with upon several horizons in this succession. They are especially numerous in the Moffat Series, in all the divisions of which they occur in countless multitudes. In the Gala and Girvan beds they are found but sparingly, and in a few thin carbonaceous bands only. The Hawick rocks, though frequently swarming with the enigmatical *Protovirgularia*—like their equivalents in Wales and

Thuringia—have not as yet afforded Graptolites. They occur, however, in abundance in the succeeding Riccarton beds, and a few have also been obtained from the more recent deposits of the Pentland Hills.

3. *Vertical Range of the Monograptidæ.*—In the present memoir I shall treat of the species of *Rhabdophora* already collected from these Scottish rocks, which belong to the family of the *Monograptidæ.* Several of these have been figured and described by our British palæontologists,—M'Coy, Harkness, Salter, Carruthers, Nicholson and Hopkinson. It is only lately, however, that the vertical range of many has been definitely ascertained. Others again have been erroneously identified, some imperfectly figured or described, while several new species await notice, and the whole subject stands in need of a thorough revision.

The Graptolites included in the family of the *Monograptidæ*—which embraces the three genera *Rastrites*, Barr., *Monograptus*, Geinitz, and *Cyrtograptus*, Carruthers—are confined exclusively to the Middle and Upper Silurian rocks. Not a single example has hitherto been detected in strata inferior in geologic position to the Bala Limestone of North Wales. Several forms from more ancient deposits have indeed been classed by palæontologists under *Graptolithus* (*Monograptus*), but there now appears to be sufficient evidence to prove that they were all in reality merely disjoined fragments of compound *Graptoloidea*. The British and Continental strata, long known as affording in great abundance species truly belonging to the family, were formerly assigned to the epoch of the Lower Silurian on insufficient evidence, and are now known to appertain either to the Llandovery or to the true Upper Silurian.

The range of the genus *Monograptus* is included between the horizons of the Bala and Aymestry Limestones. *Cyrtograptus* has nearly the same vertical distribution. The genus *Rastrites* seems to be strictly confined to the Llandovery, and is wanting even in the highest and lowest beds of that formation.

4. *Distribution of the Monograptidæ in Scotland.*—In Scotland the *Monograptidæ* make their first appearance in the Birkhill Shales (Upper Moffat). In the underlying deposits of the Middle and Lower Moffat beds they are wholly wanting. Striking evidence of this restriction is afforded by the circumstance that in the numerous anticlines in the districts of the Lammermuirs, Moorfoots, Leadhills, etc., where the Birkhill Shales are absent, not a single *Monograptid* has yet been detected in the highly fossiliferous Moffat Series; while in the Ettrick, Moffat, Dumfries, and South Wigton districts, where the Birkhill beds are present in force, they swarm innumerably. These Birkhill Shales not only exhibit the advent of the family, but also afford tolerably conclusive evidence of its specific culmination,—the overlying groups showing a great falling off both in species and individuals. The very numerous forms afforded by these Birkhill Shales allow us to parallel the sub-formation exactly with similar deposits in the North of England, Ireland, Thuringia, Bohemia and Scandinavia. *Monograptidæ* occur also, but in much less abundance, in the carbonaceous beds found near the

base of the overlying Gala Group, and in the equivalent strata of the neighbourhood of Girvan. In the later Hawick beds none have been detected; but they again occur in great numbers, but in very indifferent preservation, in the Riccarton beds, and a few examples have been procured from the Wenlock strata of the Pentland Hills.

These Scottish species, with but few exceptions, are found in equivalent strata in other districts. Many, however, are as yet confined to the Silurian deposits of the British Isles.

5. *Synonymy.*—The species here classed in the genera *Rastrites* and *Monograptus*, together with several other genera, were placed originally in the genus *Graptolithus* of Linnæus—a title subsequently modified by Beck and Murchison into *Graptolites*. The first improvement in classification was made by Professor M'Coy, who separated the diprionidian forms under the title *Diplograpsis* (afterwards altered to *Diplograpsus*). Unaware of M'Coy's procedure, M. Barrande eliminated from *Graptolithus* the two genera *Retiolites* and *Rastrites*, and divided the remaining forms into two subgenera—*Monoprion* and *Diprion*. Recognizing the validity of M'Coy's genus *Diplograpsus*, and following out his principle of nomenclature, Professor Geinitz next proposed the title of *Monograptus* for the forms included by Barrande under *Monoprion* and *Rastrites*—uniting these groups on the ground of their being connected by an intermediate species.

Herr Richter is almost the only observer who has strictly followed Geinitz. British palæontologists recognize the genus *Rastrites*, and class the forms which Barrande grouped in his subgenus *Monoprion* under the old generic title of *Graptolithus*.

There are several strong objections to the employment of the primitive title in this restricted sense. In the first place, it is more than doubtful if either of the species described by Linnæus as *Graptolithus* belonged to this group. Again, the title has been employed in turn for almost all the genera of the *Rhabdophora*;—from *Climacograptus*, to which it has been asserted it was applied by its founder,—to the comparatively recently discovered family of the *Dichograptidæ*, to the highly compound forms of which it is applied by Professor Hall. At the same time it is in daily use as a general title for all unplaced *Graptolithina*—an application of the term so simple and convenient that no field geologist would consent to relinquish it. It is consequently impossible to avoid ambiguity unless we employ a different title for the group in question.

There are two candidates for the post—*Monoprion* of Barrande and *Monograptus* of Geinitz.

The genus *Graptolithus* as described by Barrande did not include any branching forms, and consequently his subgenus *Monoprion* embraces exactly the same species classed by Carruthers or Nicholson in the curtailed genus *Graptolithus*. In strict justice, Barrande's term should be allowed to stand. It has, however, been subsequently modified to designate a complete division of the *Graptolithina*,[1] and has apparently been relinquished by its founder himself.[2]

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[1] *Hopkinson*, Journ. Queckett Micros. Club, vol. i. no. 6, page 8.

[2] *Defense* des Colonies, vol. iv. pp. 133, 25, etc.

The title *Monograptus*, on the other hand, was proposed for a group of species which are regarded by British palæontologists as belonging to two distinct genera; and if it is to be employed at all by them, it must be in the restricted sense in which they presently employ *Graptolithus*. The title is, however, far more definite than *Monoprion*, and is, at the same time, in perfect harmony with the principle of nomenclature in the *Graptolites* in general.

Guided by these arguments, and by the further consideration that we gain in this way a very convenient and unmistakable title for one of the most important families of the *Graptoloidea*, the title *Monograptus* is employed by Mr. Hopkinson and myself in the sense here advocated.

6. *Characteristics.*—The family of the *Monograptidæ*, as originally founded by myself,[1] included all those forms of uniserial *Rhabdophora* at that time recognized, in which the polypary was unilateral. The subsequent discovery of the unilateral and uniserial genus *Azygograptus*,[2] Nich. and Lapw., which cannot be placed here, but must be arranged with *Cœnograptus*, Hall, and its allies among the *Leptograptidæ* (=*Nemagraptidæ* of Hopkinson), necessitates a fresh diagnosis of the family. In all the known monoprionidian *Rhabdophora*, with the exception of the *Monograptidæ*, the distal portion of the attached sicula is isolated. Here, on the contrary, it lies back upon, and is affixed to, the dorsal margin of the proximal end of the polypary. The members of the family of the *Monograptidæ* as thus restricted may therefore be now defined as—

> *Unilateral Graptoloidea, in which the sicula is thrown back upon, and united to, the dorsal margin of the proximal extremity of a simple or compound monoprionidian polypary.*

7. *Development.*—The sicula of the *Monograptidæ* has been already figured by Herr Richter[3] under the title of the "*foot.*" In the great majority of the species of the family in which its presence has been recognized, it is of very diminutive size, rarely exceeding one-twentieth of an inch in length. In some forms, however, as in *Monograptus gregarius*, Lapw., Plate X. Fig. 12*c*., its length exceeds one-fourth of an inch, and the development of the polypary can be easily followed step by step. In this family the sicula is identical in form with that in the bilateral *Graptoloidea*, which has been already described.[4] The polypary originates from a point near the broad end of the sicula; but, instead of proceeding freely outwards as in the bilateral forms, it grows backwards along the distal portion of the sicula itself, to which it adheres by its dorsal surface, and passing beyond it, is continued onwards in the same general direction.

As in other families of the *Graptoloidea* there occur, now and again, remarkable monstrosities, caused by a departure from the normal method of development. Variations of this nature are met with in the species *Monograptus lobiferus*, M'Coy, etc. In these abnormal examples, which occur in abundance in some localities, the *sicula* at the same time that it throws off the single polypiferous stem in the usual manner, behaves also as if it were itself the primordial hydrotheca of a second stem, which grows outwards in the opposite direction to the normal one, and frequently rivals it in all its characters and proportions. In this way the polypary becomes actually bilateral. It is probable that all the *Graptoloidea* ought to be regarded as colonies of siculæ held together by a common body, and on this view the occasional presence of this peculiarity can hardly excite astonishment. We meet indeed with a parallel case in *Didymograptus*, where the sicula seems to be the primordial and common theca of two distinct monoprionidian series.

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[1] Geol. Mag. Vol. X. p. 555, Tab. I.

[2] Annals and Mag. Nat. Hist. 1875.

[3] Zeitschrift d. Deutschen Gesellsch. 1871, Taf. v. fig. 1.

[4] Geol. Mag. Vol. X. p. 501; and Quart. Journal Geol. Soc. vol. xxxi. p. 639.

§ II.—Genus Rastrites, Barrande.

The genus *Rastrites*, founded by Barrande in his classical work on the Graptolites of Bohemia, is most intimately allied to *Monograptus* (*Graptolithus*); differing from it chiefly in the fact that the hydrothecæ, instead of being in contact or overlapping, as in that genus, are invariably isolated. Its nearest allies are the forms of the type of *Monograptus Sedgwickii*, Portl. sp., in which the hydrothecæ just touch each other at their bases. In some examples of that group, also, while the thecæ of the distal portion of the polypary are truly in contact, those near its proximal end are isolated. This is notably the case in the form *Monograptus triangulatus*, Harkn. sp., in which it often happens that none of the hydrothecæ are actually in contact; and thus, broadly speaking, it sometimes becomes a veritable *Rastrites*. The importance of this fact was overestimated by Professor Geinitz, who concluded that it was fatal to Barrande's view of the generic distinctness of *Rastrites* and *Monoprion*; and accordingly united them in his own new genus *Monograpsus*.[1]

Richter is perhaps the only palæontologist who distinctly coincides with Geinitz in this opinion; but some of our British observers have shown indications of a tendency to follow in the same direction.

It may at once be conceded that *Monograptus triangulatus* is the connecting link between the two groups; and we may even go farther and admit that there is much to be said in favour of the theory that it was the direct ancestor of *Rastrites peregrinus* and its allies. But if the genus *Rastrites* is to be suppressed because of the existence of this dubiously transitional species, the great majority of the admitted genera must also be abolished on similar grounds. In seeking generic characters among fossils like the *Graptolites*, we are perforce restricted to those afforded by the hard parts of their external skeleton. No genus is more strongly individualized in this respect than *Rastrites*. It is impossible to overlook the fact that all its species are far more intimately allied *inter se* than they are to any species of *Monograptus* whatsoever. Thus, for the purposes of science, these forms must be united under some distinctive title. Whether the group thus constituted has a generic or subgeneric value must be left for future determination. In the actual state of our knowledge it may most conveniently be retained as the genus *Rastrites.*

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[1] Die Graptolithen, s. 18.

M. Barrande never appears to have seen the *virgula* (solid axis) in this genus, but to have inferred its existence from analogy alone. Nor has it been mentioned as visible by any subsequent observer. On the other hand, its apparent absence has been remarked. In Plate X. Fig. 1, is figured an example of *Rastrites peregrinus,* Barr., in which the virgula is prolonged as a naked filament beyond the distal extremity of the polypary. Its presence in the genus is thus placed beyond dispute.

1. Rastrites peregrinus, Barrande. Plate X. Figs. 1 and 5.

Rastrites peregrinus, Barrande; Grapt. de Bohême, plate iv. figs. 3 and 6. Harkness, Quart. Journ. Geol. Soc. vol. vii. plate i. fig. 1. Nicholson, Quart. Journ. Geol. Soc. vol. xxiv. plate xix. figs. 23 and 24.

Monograpsus peregrinus, Geinitz; Die Graptolithen, Taf. v. figs. 11 and 12. Richter, Zeitschrift d. Deutschen Gesellsch. 1853, Taf. xii. figs. 29, 30, 31.

Rastrites Linnæi, Barrande; Grapt. de Bohême, plate iv. fig. 3.

The foregoing list embraces references to all the more important figures of this very well-known species, in what may be regarded as its typical aspect. In addition to the type form, the Scottish rocks also afford the following well-marked variety.

Var. hybridus. Plate X. Fig. 5.

Monograpsus Linnæi, Geinitz; Die Graptolithen, Taf. v. fig. 10 *a, b.*

Polypary about one inch in length, arcuate, incurved. Hydrothecæ 16 to 20 to the inch, and about twice as long as the interspaces. In this variety the interspaces are larger than in the typical form; the hydrothecæ are shorter, slightly inclined, and frequently have their apices reflexed.

Locality.—Typical form, found everywhere in the upper zones of the Birkhill Shales at Dobbs Linn, Craigmichan, Dumbreddan, etc. Var. *hybridus* is confined to the highest zones of the same formation.

2. Rastrites maximus, Carr.

Rastrites maximus, Carruthers; Geol. Mag. 1868, Vol. V. Plate V. Fig. 14.

Locality.—Common in the highest beds of the Birkhill Shales at Mountbenger Burn, Dobbs Linn, Garple, Frenchland, etc.

3. Rastrites distans, sp. nov. Plate X. Figs. 2 *a, b.*

Rastrites Linnæi, Nicholson; Quart. Journ. Geol. Soc. vol. xxiv. plate xix. figs. 25 and 26.

Polypary filiform, one to two inches in length, straight or but slightly curved. Hydrothecæ isolated, perpendicular to the general polypary; and (2) the shape of the compressed hydrothecæ, which are triangular in form, with the apertural margin precisely normal to the general line of the virgula. The polypary has consequently a remarkably neat and compact appearance, leading to its immediate identification.

It somewhat resembles *Monogr. intermedius*, Carr.; but in that species the hydrothecæ are arranged on the *convex* margin of the polypary; they are different also in their general form. Perhaps its most intimate ally is *Monograptus concinnus*, Lapw., from which it differs mainly in the size of the adult polypary, and in the details of the hydrothecæ.

M. Barrande figures fragments of at least two distinct species under this title (Grapt. de Bohème, plate 2, figs. 16-18). His largest figure (fig. 16) is the only one to which his very full diagnosis can be applied, and it holds good for the form here described. Fig. 17 of his plate is *Monograptus gregarius*, Lapw., and fig. 18 has probably been taken from a young example of some species of the *Sedgwickii* type. All palæontologists who have subsequently referred to the species have very naturally fallen into similar errors. Several distinct species of the *Nilssoni group* have been identified with this typical form, which has itself never been refigured.

The foregoing description has been drawn up from specimens in the Cabinet of Professor H. A. Nicholson, collected by him in the Lower Ludlow rocks of Leintwardine.

Locality.—A few very doubtful fragments only have been procured from the Birkhill Shales of Mountbenger; and from the Gala beds of Darnick, near Melrose.

6. MONOGRAPTUS INTERMEDIUS, Carr. Plate X. Figs. 10 *a—e*.

Graptolithus intermedius, Carruthers; GEOL. MAG. 1868, Vol. V. Pl. V. Fig. 18.

Graptolites Nilssoni, Baily; Characteristic Brit. Foss. plate ix. figs. 2*a*, *b*.

Polypary from three to four inches in length, and with a maximum diameter of one-twentieth of an inch; distal portion broadly arcuate, proximal portion normally strongly recurved. Hydrothecæ, acut-angular, 20 to 25 to the inch, adpressed to the periderm, in contact only; outer margin straight, apertural margin inclined.

As a rule the proximal portion of the polypary in this species is sharply recurved, and under this aspect it was originally figured and described by Mr. Carruthers. It sometimes happens, however, that this curvature is less pronounced, and there is a gentle and similar curve throughout the whole length of the polypary. (Comp. Plate X. Figs. 10 *c*, *b*.)

Fragments from the earlier extremity of the polypary are, except for their peculiar dorsal curvature, almost inseparable from similar fragments of *M. Nilssoni*, Barr. In the adult portion the broad triangular denticles are very characteristic. I am disposed to refer the *Graptolithus acutus* of Mr. Hopkinson to this species, fragments of which from the neighbourhood of the proximal extremity often answer precisely to his description, and, like his examples, generally occur in matted groups. Compare Plate X. Fig. 10 *c*.

Var. INVOLUTUS. Plate X. Fig. 11.

Graptolites Nilssoni, Nicholson; Quart. Journ. Geol. Soc. vol. xxiv. plate xx. fig. 18.

What seems to be a variety of this species is not uncommon in the highest zones of the Birkhill Shales. It is enrolled in an irregular spiral, and the earlier denticles frequently have their extremities recurved.

Locality.—Typical form, Upper beds of the Birkhill Shales at Dobbs Linn, Frenchland, Garple, Duffkinnel.

7. MONOGRAPTUS GREGARIUS, sp. nov. Plate X. Figs. 12 *a*—*c*.

Graptolithus Nilssoni, Barr.; Grapt. de Bohême, pl. ii. fig. 17.

Graptolites Nilssoni, Harkness; Quart. Journ. Geol. Soc. vol. vii. plate i. figs. 7 *a*—*d*. Nicholson, Quart. Journ. Geol. Soc. vol. xxiv. plate xx. fig. 19.

Polypary curved, short, rigid; one to one and a half inches in length, and with a maximum diameter of one-twentieth of an inch. Hydrothecæ arranged on the convex margin of the polypary, adnate to the periderm, in contact only, triangular in form; outer edge concave, apertural edge straight, at right angles to axis of polypary, denticle conspicuous.

This is one of the best characterized species of the group. It has hitherto been strangely confounded with *Monogr. Nilssoni*, with which it has scarcely a character in common. The polypary is, as a rule, about one inch in length; but sometimes examples are met with which have an extent of 2½ inches. These have a superficial likeness to similarly sized examples of *M. intermedius*. From all other species the size and shape of polypary at once distinguish it.

The *sicula* in *Monogr. gregarius* may fairly be termed gigantic. It often reaches a length of one-fourth of an inch before the primordial theca is developed, and its broad extremity communicates a peculiarly blunt appearance to the proximal end of the adult polypary. The specimen figured (Plate X. Fig. 12*c*) is from the Skelgill Shales of the Lake District, but the sicula is quite as conspicuous in Scotch and Irish examples.

Locality.—This species characterizes a distinct zone of the Birkhill Shales, in which it swarms in extraordinary profusion at Dobbs Linn, Frenchland, Garple, Dumbreddan, etc.

8. MONOGRAPTUS ATTENUATUS, Hopkinson. Plate X. Figs. 9 *a*—*d*.

Graptolithus attenuatus, Hopkinson; GEOL. MAG. 1872, Vol. IX. Plate XII. Figs. 3 *a*—*c*.

The most slender species of the *Monograpti* yet discovered. Mr. Hopkinson gives a very full and accurate diagnosis of it. He believes, however, that its hydrothecæ are separated from each other by a slight interval: and that it is in this respect allied to *Rastrites*. Examples preserved with a portion of their relief prove, however, that, as in all species of this type, the hydrothecæ are truly in contact.

Portlock's original figure of his *Graptolithus tenuis* is certainly very indifferent, but there can be no question that it was intended for the species we are describing. The Graptolitic schists of Limehill, whence his examples were procured, are in certain localities crowded with this form; and no other species of the *Nilssoni* group seems to occur there. The figures given on Plate XI. (Figs. 3 *l*, *m*, *n*) are from specimens collected from these beds by myself. The Irish examples show all the peculiarities of the species as given above — the characteristic dorsal curvature of the polypary, the approximate and obscure or prolonged denticles of the distal portion, and the distant, pointed or reverted denticles near the proximal extremity.

Many of the same features seem to be characteristic of the form *Graptolites discretus* of Professor Nicholson; which is probably identical with the present species.

Locality.—*Monograptus tenuis* is perhaps the commonest fossil of the Birkhill Shales, occurring everywhere in great abundance, as at Ettrickbridgend, Dobbs Linn, Frenchland, Belcraig, etc. It occurs also but very rarely in the succeeding Gala Group at Darnick Bridge, Eddleston Waterhead, Overshiels, etc.

12. Monograptus Sandersoni, sp. nov. Plate XI. Figs. 2 *a*—*e*.

Polypary of great length, distal portion slightly arcuate, and having a maximum diameter of one-thirtieth of an inch, proximal portion long, filiform and sharply incurved. Hydrothecæ 14 to 18 to the inch, adpressed to the concave margin of the periderm, in contact only; long and narrow, with inclined apertural margin and an acute but inconspicuous denticle.

Commencing with an extremely slender flagelliform portion, the polypary augments its diameter very slowly, so that nearly a foot of length is attained before the point of maximum width is reached. The adult organism must have possessed a length of more than eighteen inches. The hydrothecæ, which are less than one-fiftieth of an inch in average diameter, are somewhat sacculate near their distal end, but for the greater portion of its length the exterior edge of each is quite straight. The margin of the aperture is invariably inclined. The denticle, though remarkably acute, is never so prominent as in *Mono. tenuis* or *Monogr. Nilssoni*.

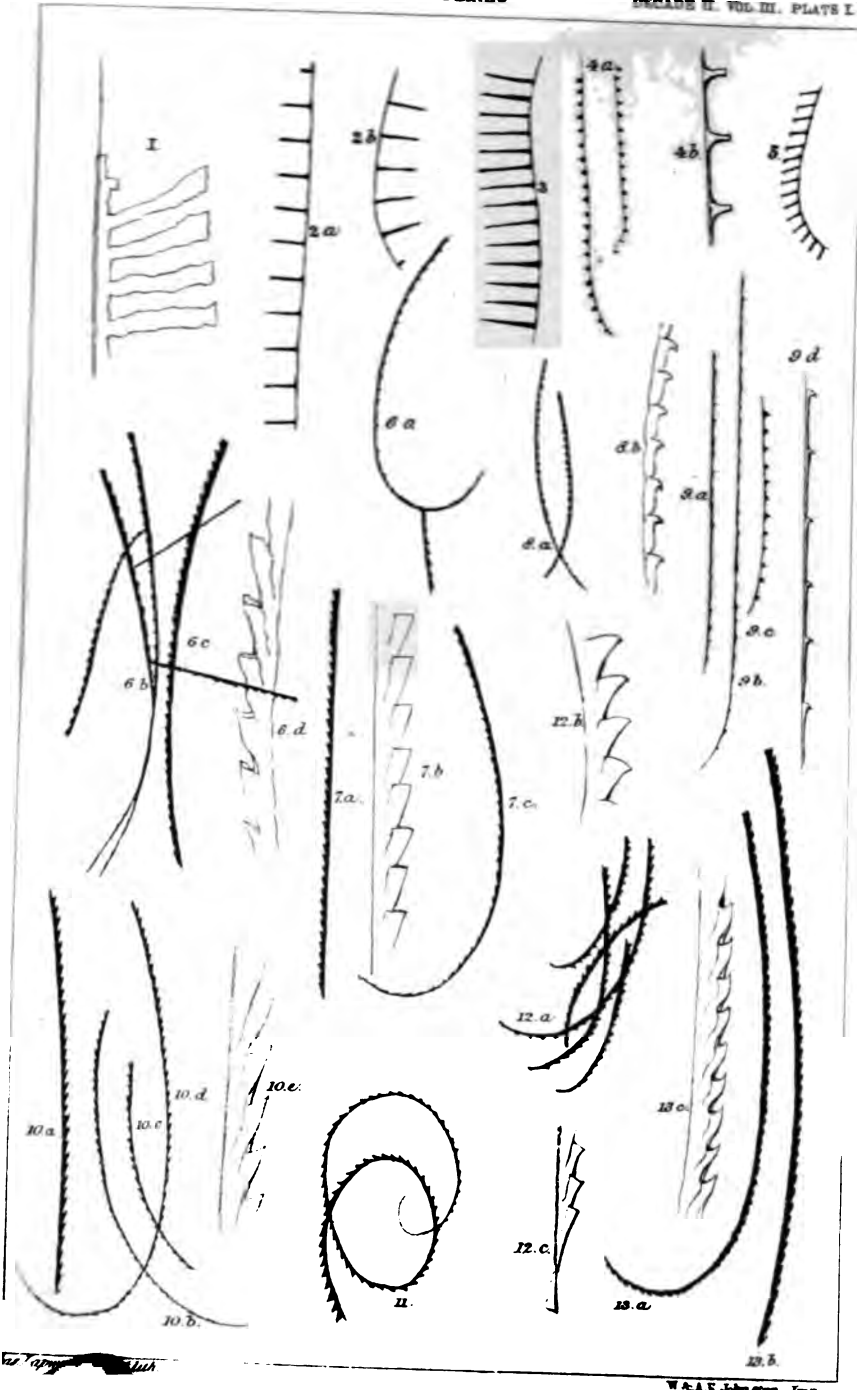
Straight fragments from the neighbourhood of the proximal extremity may sometimes be confounded with *Mono. attenuatus*. Hopkinson. The long slender polypary and narrow peculiarly shaped hydrothecæ at once distinguish it from all other forms.

I dedicate this species to my friend W. A. Sanderson, Esq., of Galashiels, without whose generous assistance the complete description of many of these forms would have been practically impossible.

Locality.—Birkhill Shales, Middle zones; at Dobbs Linn, Frenchland, Belcraig.

13. Monograptus concinnus, sp. nov. Plate XI. Figs. 1 *a*—*e*.

Polypary curved, of great length; gradually enlarging through a very narrow incurved proximal portion to a maximum diameter of one-sixteenth of an inch. Hydrothecæ 20 to 24 to the inch, adnate



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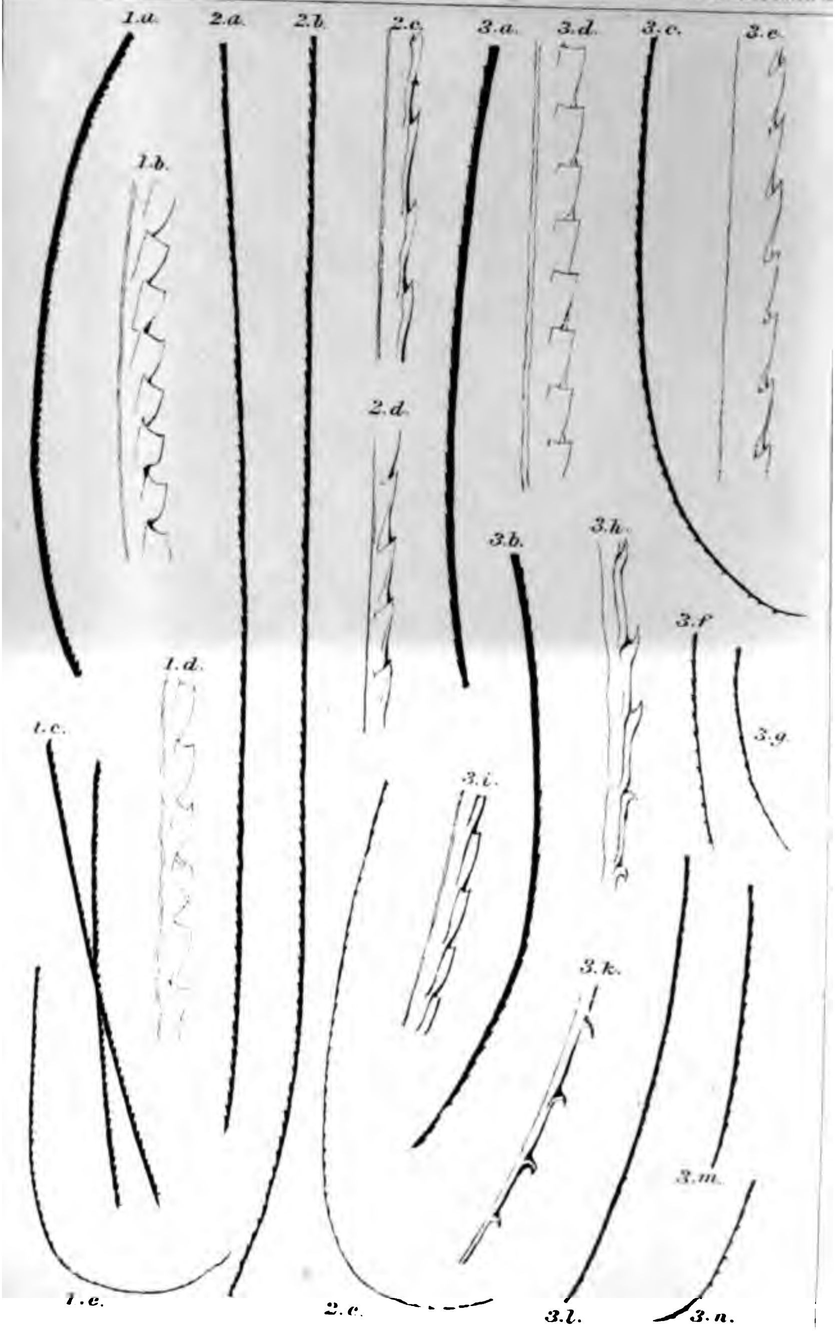
W. & A. K. Johnston, Imp.

Scottish Monograptidæ



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Scottish Monograptidæ

to the concave margin of the periderm, without overlap; conical in form; outer margin slightly convex, apertural margin deeply concave, and normal or somewhat everted.

The hydrothecæ in the adult portion of the polypary are broad cups, nearly as wide as long, and with large and strongly everted apertures. Fragments from this extremity would be unhesitatingly assigned by most palæontologists to *M. Hisingeri*, Carr. (*sagittarius*, His., of authors). The proximal portion of the polypary again greatly resembles that in *M. Nilssoni*, Barr., and it would at once be referred to that species.

The characters afforded by the hydrothecæ of the proximal end, when carefully noticed, are perhaps sufficiently distinctive. Their outer margins are often somewhat convex, while the apertural edge is invariably deeply concave, and the pointed denticle thus formed is very different from the almost rectangular denticle in *M. Nilssoni*. I regard, however, the separation of this form as a distinct species as merely provisional. A better acquaintance with *Monogr. Nilssoni* may prove that the distal extremity of that form is provided with the large cup-like thecæ of *Monograptus concinnus*.

Locality.—Birkhill Shales of Dobbs Linn, Belcraig, Garple, etc.

EXPLANATION OF PLATE X.

FIG. 1. *Rastrites peregrinus*, Barr., magn.; showing the distal prolongation of the virgula. Coal-pit Bay. (Coll. W. Swanston, Esq.)
„ 2*a*—*b* „ *distans*, Lapw., nat. size. Meigle Hill, Selkirkshire.
„ 3. „ *Linnæi*, Barrande; Grapt. de Bohême, plate iv. fig. 2.
„ 4*a*—*b* „ *capillaris*, Carr., 4*a*. nat. size; 4*b*. magn. Duffkinnel.
„ 5. „ *peregrinus*, Barr., var. *hybridus*. Belcraig Linns, Moffat.
„ 6*a*—*d* *Cyrtograptus Carruthersi*, Lapw.; 6*a*. proximal portion; 6*b*. primary branches; 6*d*. magn. Elliottsfield, Roxburghshire.
„ 7*a*—*c* *Monograptus Nilssoni*, Barr.; 7*c*. proximal extremity; 7*a*. adult portion; 7*b*. magn. Leintwardine. (Coll. Prof. H. A. Nicholson.)
„ 8*a*—*b* „ *Salteri*, Geinitz; 8*a*. nat. size.; 8*b*. magn. Caddonwater Head, Selkirkshire.
„ 9*a*—*d* „ *attenuatus*, Hopk.; 9*d*. magn. Dobbs Linn, and Riskinhope Burn.
„ 10*a*—*e* „ *intermedius*, Carr., 10*e*. magn. Duffkinnel, Dumfriesshire. (Coll. Prof. H. A. Nicholson.)
„ 11 „ *intermedius*, var. *involutus*. Dobbs Linn.
„ 12*a*—*c* „ *gregarius*, Lapw.; 12*a*. nat. size; 12*b*. magn.; 12*c*. proximal extremity showing sicula. Dobbs Linn.
„ 13*a*—*c* „ *argutus*, Lapw.; 13*a*. proximal extremity, 13*b*. adult portion, 13*c*. magnified. Dobbs Linn, Dumfriesshire.

EXPLANATION OF PLATE XI.

FIG. 1*a*—*e* *Monograptus concinnus*, Lapw. 1*a*. distal portion; 1*b*. magn.; 1*c*. central portion; 1*d*. do. magn.; 1*e*. proximal portion. Dobbs Linn.
2*a*—*e* *Monograptus Sandersoni*, Lapw. 2*a*. *b*. distal portions; 2*c*. *d*. do. magn.; 2*e*. proximal end. Dobbs Linn.
3*a*—*n* *Monograptus tenuis*, Portlock sp. 3*a*. *b*. *c*. adult portions; 3*d*. *e*. do. magn.; 3 *f*. *g*. proximal extremities; 3 *h*. *k*. do. magn. Dobbs Linn and Ettrickbridgend. 3*l*. *m*. *n*. Irish examples. Limehill, Pomeroy, Tyrone.

In these Plates the figures in black are of the natural size. Those in outline are magnified; reduced to a uniform scale of five diameters from drawings made with the camera lucida.

REVIEWS.

I.—Critical Observations on Theories of the Earth's Physical Evolution. By Capt. C. E. Dutton, U.S.A. (The Penn Monthly. Philadelphia, May, 1876.)

THE author remarks that there are few great problems in physical science, which have been studied so long, and with such meagre success, as that which involves the dynamical causes of the present inequalities of the earth's surface. Of the effects of the force which has produced these, we already possess considerable knowledge. Of its origin we know but little; unless the theory which has recently attracted much attention, and of which Mr. Mallet, F.R.S., is the most conspicuous advocate, be considered a true solution. The earth is assumed to be a mass, which is hot within and cold without, and to be continuously radiating into space its interior heat. In consequence of this loss of heat from the interior, the portions which suffer a loss of temperature contract; while the portions near the surface, remaining at a temperature due to their position in space, suffer no change of volume. As the solid crust sinks together to follow down the shrinking nucleus, the *work* expended in mutual crushing, and dislocation of its parts, is *transformed into heat*, by which, at the places where the crushing sufficiently takes place, the material of the rock so crushed, and of that adjacent to it, is heated to fusion. The access of water to such points determines volcanic eruption. Volcanic heat therefore is one result of the secular cooling of a terraqueous globe, subject to gravitation; and needs no strange or gratuitous hypothesis as to its origin. Mr. Mallet also brings within the range of the same system of causation the origin of terrestrial features. They are unquestionably associated; and any theory must similarly connect them. The questions which will be asked, and to which answers will be offered, are:

First, admitting that the earth is a cooling body, and that it is contracting internally, is the cause appealed to quantitatively sufficient to produce the effect ascribed to it?

Second, admitting (for the sake of argument only) that the assigned cause is sufficient, does it explain, and is it consistent with known facts, and the observed structure of the earth's surface?

In connexion with the first inquiry, it may be remarked that Mr. Mallet has not attempted to indicate the stage, which the secular cooling of the earth has now reached, but has arbitrarily assumed it to be an advanced one. This is quite necessary to the validity of his hypothesis. For it is obvious that if the secular cooling has been hitherto small, it is insufficient to explain the various known phenomena of structure, which, if produced by contraction at all, would have required a very great amount of it.

Sir W. Thomson has made an application of a proposition in Baron J. J. Fourier's "Théorie Analitique de la Chaleur" to the case of a cooling globe. The particular problem which he proposed was, What has been the duration of the cooling, and what is the present distribution of subterranean temperature? He took the highest reasonable value of initial temperature, viz. 7000° Fah., which may be regarded as extravagantly high, in order to avoid any objections which might be made by geologists. And he took the mean present rate of increase of temperature in descending, around which nearly all results of observation tend to cluster, viz. one degree for fifty-one feet; while the conductive power of the commoner kinds of rock and their specific heat were determined by experiment. From these data he deduced the period of cooling, and the present distribution of temperature within the globe, arriving at the following results. The period since the globe solidified [supposing it to have become solid throughout simultaneously*] cannot be less than twenty million, nor greater than four hundred million of years. Below the depth of one hundred and forty miles the amount of cooling has been immaterially small—the nucleus being nearly as hot as ever. Various criticisms have been made respecting the quantities used by Sir William in this computation, but after making every allowance for possible errors, the following conclusion still remains from his application of the theorem: That no cooling has taken place to any important extent to a greater depth than three hundred miles. The ratio of the cooled crust to the uncooled nucleus thus deduced would be about the same as that of the peel of a fair-sized Havana orange to the edible interior.

If this argument of the most eminent physicist now living cannot be invalidated, what becomes of Mr. Mallet's hypothesis? It fails utterly by the destruction of his most important premiss. He assumes a large amount of cooling and a large amount of consequent contraction. It results from Sir William's argument that there has been only an insignificant amount of either. The difference is one which admits of no compromise; for the two quantities do not lie within the same order of magnitude, and by no possible revision can they be made conformable to each other. One of the two must be utterly wrong and untenable. The exact point of conflict will be found in the different interpretations which they place upon the observed rate, or rates, of increase of temperature with depth. Sir William adopts without question the view that it is an index of the aboriginal heat still remaining within the earth at the present stage of its secular cooling. Mr. Mallet holds that it is an indication of heat developed by secondary causes, produced by a stage of cooling incomparably more advanced. It may be noted here that Mr. Mallet's view is a "gratuitous assumption"; the very kind of assumption which he asserts to be unnecessary to his hypothesis. The older view, although it may not be capable of the rigorous demonstration which physical problems sometimes require, rests upon some substantial evidence. We are indebted to no one more than to Mr. Mallet for probable evidence that the seat of volcanic action is not very deep; and if the heat encountered in mines, and artesian wells, is not good evidence of high temperature near the surface, volcanos are.

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* The sentence enclosed in *square* brackets is inserted by the Reviewer.—Edit. Geol. Mag.

These two indications are quite concordant, and we have no other tangible evidence bearing upon the subject, either one way or the other. Of his own view Mr. Mallet has produced no proof whatever, but assumes it at once, because it suits his hypothesis. Although the burden of proof is clearly with him, an appeal to it may be regarded as indecisive. Nor is this necessary: for his argument may be more directly assailed. If it be sought to invalidate the application of Baron Fourier's theorem by attempting to show that the heat found in mines and wells is due in any appreciable degree to the work of a subsiding crust, the effort must fail. For let us suppose that the earth has dissipated at least one-fourth of its aboriginal heat. If it has dissipated more, then the argument will be stronger. Then, neglecting for a moment the heat arising from the subsiding crust, and all other secondary or extraneous additions, the rate of increase of temperature with depth would be in portions near the surface not far from one degree F. per 1000 feet of descent. But the mean observed rate of increase is some seventeen times greater than this; and, if the observed rate is due to the secondary cause, then we should have the remarkable conclusion forced upon us, that only the seventeenth part of the heat radiated into space is original, the remainder being generated by the work of its sinking crust; which is quite impossible. If a more advanced stage of cooling than one-fourth be assumed, then the impossibility becomes all the more conspicuous: if the cooling be much less advanced than one-fourth, the quantitative basis of Mr. Mallet's hypothesis disappears. If the proposed modification proved anything, it would prove that the subsiding crust could generate an enormously greater quantity of heat than the earth originally possessed; whereas we know that, in any case, the quantity so generated must be far less. The applicability of Fourier's theorem to the cooling earth cannot be impaired therefore by the proposed objection. The result of its application is the conclusion, that the secular cooling of the earth is still in its earlier stages; that the cooled portion is comparatively speaking only skin-deep; and that the nucleus is very nearly as hot as ever. If this conclusion is ever weakened, it will be by the effect of laws and processes which are at present unknown.

We have quoted the above paragraph in full, because it expresses Captain Dutton's conclusions upon a question that has been much debated of late, yet rarely with so much clearness. He goes on to say that the foregoing argument was first presented by the Rev. Osmond Fisher, of Cambridge (England), and subsequently by himself without any knowledge of Mr. Fisher's analysis. The conclusions reached were identical. The writer referred to certainly did apply the results of Sir William Thomson's investigation to determine the amount of inequalities of the earth's surface, which might be produced by the shrinking due to cooling, and found it to be very far too small to account for those which exist. But he *did not* directly apply this result to the refutation of Mr. Mallet's theory, as Captain Dutton has done. He approached that question in a different manner, and in a separate publication, arriving by a different road at exactly the same conclusion with Captain Dutton. It is, however, apparently to Mr. Fisher's paper "On the Inequalities of the Earth's Surface" that Captain Dutton refers, and we would make a slight correction in his allusion to it. Captain Dutton writes: "That gentleman, as if doubting the result of his own elaborate computations, remarks that it is difficult to conceive any source, other than contraction, of the intense corrugations which meet our observation, and suggests that metamorphism and consolidation are accompanied by a contraction of volume." We do not understand Mr. Fisher as appealing to this cause to help to account for the globe's contraction, but rather as making it an objection to Babbage's theory of the elevation of sedimentary deposits through their lower parts becoming heated. The doubts expressed were not as to the results of his own computations, but rather as to the truth of Sir William's supposition, upon which he had based them, viz. that the earth is solid.

To return to Captain Dutton's article. In seeking for the causes which have produced the physical features of the earth's surface, geologists require a supply of mechanical force: but that arising from contraction from cooling is many times less than the quantity required. But, if it be replied that the data on which this result is obtained may still be erroneous, the most just course will be to inquire whether, supposing the contractional theory be correct, it will explain the facts to be accounted for.

1. The origin of continents has been attributed to inequalities of conductivity of different parts of the crust; and the escape of heat, and consequent contraction, has been supposed less beneath the land than beneath the ocean. But continents, though they are geographically units, are in their geological relations highly complex aggregates. Each portion of them has its own history, its own law of development, its own stratigraphical series; and still possesses its structural peculiarities. And to be unmindful of such facts would be to incur the risk of serious errors.

The vertical movements have not been uniform. Certain areas have repeatedly undergone submergence and emergence alternately; so that they must have been formerly regions of great contraction, and have subsequently become regions of less. All those great prominences, to which the term table-lands is usually applied, and which form the most elevated portions of the earth, are covered with heavy beds of marine strata of Mesozoic or Tertiary age—so far at least as is now known. The Himalayan plateau reveals great bodies of marine Tertiary beds, at an altitude of 16,000 feet above the level of the sea. According to the hypothesis then, the rate of contraction in this locality must have been, prior to the Eocene, greater than the average; but since the Eocene it must have been less. The quantitative sufficiency of this cause to produce continents might remain without question, if geology had furnished proof that it had been acting continuously and cumulatively in one direction throughout the whole period of evolution. As it is, whatever values be assigned to the required data, some one or more of them—the time, or the difference of conductivity, or that of the mean temperature of different portions of the crust—will be involved to an extent far greater than physicists or geologists will be disposed to grant.

2. The subject of plications is one to which the contractional hypothesis is supposed to be especially applicable. The astonishing attitudes, the extreme disturbance and manifestations of energy, which they frequently display with endless diversity, fill the mind of the geologist with wonder and awe. Out of the vast array of facts the following generalizations clearly appear;—1. They are aggregated in great belts, where the folds lie near and approximately parallel to each other, with a high degree of flexure; while the neighbouring regions are comparatively but little so disturbed. 2. Plications are the invariable concomitant of mountain forms. Sometimes the folds themselves form the mountains and ridges. Sometimes they lie upon the flanks of ranges, which are composed of granite cores, which seem to have risen up out of the depths, and pushed the strata aside to find exit. There is, however, almost an exception to this generalization in the country drained by the Colorado river. Here, and also in the Great Basin, the rocks are cut by great faults, and uplifted thousands of feet in tables, with strata nearly horizontal, or tilted so that one side of a range shows the surface, and the other the faulted edges of the strata. The converse proposition, that plicated regions are mountainous, is not always true. 3. Plications occur in regions of *maximum* sedimentation—that is, where large bodies of sediment have been accumulated rapidly. The Palæozoic strata of Great Britain, and the Appalachians, are ten or fifteen times as thick as those of the Mississippi Valley and of Central Russia. The former are plicated; the latter not so. The Alps, Jura, Urals, Himalayas, Andes, and Rocky Mountains, are all plicated, and are regions of maximum sedimentation. The reverse proposition is also true, that regions of *minimum* sedimentation are comparatively undisturbed. 4. The epochs at which the plications commenced were those during, or immediately following, the deposition of maximum sediments. It has frequently happened that a region has received deposits through a long series of epochs, and in such cases a general unconformity shows the plications to have been continuous also. This generalization is important; for it suggests that the relation is something more than a mere coincidence. 5. In some plicated regions there may be observed a marked coincidence, or general parallelism between the directions of the axes of flexure and the axes of maximum sedimentation. This is the case with the Appalachians, the Alps, and the Jura. In the Rocky Mountains the thicker strata do not occur in elongated narrow belts having a uniform trend; but are broad and irregularly defined. But there is also less regularity in the plications and forms of disturbance.

Now the contractional theory assumes plicated regions to occur along lines of weakness in the crust. But does it suggest any reason why those places where the strata lie thickest should become the weakest? or why the particular epoch of disturbance should coincide with, or immediately follow, the epoch of deposit? Whatever may be the meaning of these correlations, it is quite certain that they are not accidental; and it cannot be for one moment admitted that such a gratuitous assumption, as these supposed lines of weakness, is any explanation of them at all.

Calling attention to the extreme displacement seen, the author remarks there is still no chaos. In New England and the Middle States the beds preserve their positions as perfectly as when they were deposited. However vast the disturbing force may have been, we may well wonder at the gentleness and ease with which they have been lifted up or let down. As if to remind us how destructive the force might have been, we find here and there a few acres which have unmistakably been subject to lateral thrusts, in consequence of the sliding of a large mass down a steep incline, or some other local cause, and the strata have "gone into 'pi.'" This preservation of continuity suggests that the force which produced the movements was a *minimum* force—that is, a force having the smallest intensity which is capable of producing the movement. But this is demonstrably a system of forces acting upwards at the anticlinals, and downwards at the synclinals. It is equally capable of demonstration that, of all possible modes in which a force could be applied to produce a fold, the horizontal or tangential application would require the greatest intensity. It is the latter force which the contractional hypothesis supplies; and the probable result of it would be, not flexures, but the annihilation of all traces of stratification. It is a law of mechanics that tendencies to rupture increase with the cubes of dimensions, while resistances to rupture increase only with the squares. The masses under consideration are collectively of the extent of states and empires; the individuals are mountain ranges and valley bottoms; and their coherence in the presence of the forces which are adequate to move them becomes, by virtue of the foregoing law, a vanishing quantity. Such masses, under the action of the supposed force, would be the merest rubble, and quite incapable of preserving their integrity. The action has frequently been illustrated by subjecting a pile of paper to compression edgewise. A closer analogy would be presented if the paper were reduced to ashes or charcoal before applying the pressure. A better, though far from an adequate one, may be found in the chaos produced in the Arctic regions, where a great ice-floe is driven upon a rocky coast.

Captain Dutton had intended to have adduced other objections to the contractional hypothesis, depending on the arrangement of mountain systems, their structure, and the figure of the earth itself. But he considers the arguments above given sufficient to overthrow the theory. He has no theory to put in the place of it; but promises in a future article to indicate a few conditions, to which any such must conform, before it can claim even a conditional acceptance. The importance of the subject, and the philosophical spirit in which it is here treated, must be our excuse for the length of the above notice. The American geologists have, as a body, given more attention to mechanical geology of late, than those of this country; and Captain Dutton seems peculiarly fitted to cope with its difficulties.

The idea that mountain elevation has been in some way connected with areas of maximum sedimentation may be found in the introduction to Hall's Palæontology of New York (1859). We do not remember to have seen the opinion adopted by any English geologist, but it is unquestionably a point of great importance to determine whether it is a true generalization; since, if it be so, it is a most important one.

Without adding any suggestions of our own upon this grand subject, we await with interest Captain Dutton's next communication to the "Penn Monthly" Magazine.

II.—RUDIMENTS OF GEOLOGY. By SAMUEL SHARP, F.S.A., F.G.S. Second Edition. (Stanford, London, 1876.)

AS the first edition of this work was reviewed in the pages of the GEOLOGICAL MAGAZINE so recently as August, 1875, it will only be necessary, on the present occasion, to take notice of the additions and alterations which have been introduced into it, now that it has reached a second edition. All the changes made are, we think, clearly in the direction of improvement. By enlarging it from 126 to 204 pages, the author has been enabled to treat the subject of Physical Geology in a rather more adequate manner than was attempted in the first edition; while several portions of his epitome of stratigraphical geology have been rewritten, and greater clearness and accuracy imparted to them; he has also shown a commendable anxiety to bring the work up to date by noticing the results even of the most recent researches. An index, the want of which was certainly a blemish in the first edition, has been supplied in the present; and we may now recommend this little manual as being among the best of those introductory text-books of geology, the multiplication of which may be accepted as a gratifying proof of the increasing demand for elementary instruction in the science.

III.—PRODROMUS OF THE PALÆONTOLOGY OF VICTORIA; OR FIGURES AND DESCRIPTIONS OF VICTORIAN ORGANIC REMAINS. By F. M'COY, etc., etc. Decade III. pp. 40, 10 plates. (Melbourne, 1876.)

THE third Decade of Prof. M'Coy's Victorian Palæontology contains descriptions and figures of several fossils of great interest. The first plate is devoted to figures of portions of the jaw of *Thylacoleo carnifex*, Owen, representing specimens derived from the identical locality from which Prof. Owen's original example was obtained, Lake Colungulac, Victoria. According to Prof. M'Coy, his late acquisitions suggest certain modifications of Prof. Owen's view as to character and homologies. One, a specimen of the upper jaw, exhibits for the first time all the teeth in front of the carnassial *in situ*. Prof. M'Coy finds that the Victorian individuals differ sufficiently from the N. S. Wales specimens used by Prof. Owen for the completion of his memoir on *T. carnifex* in the Philosophical Transactions as to suggest specific separation. Should this view be accepted, he proposes to restrict the name *T. carnifex*, Owen, to the portion of the upper jaw figured and described from the original Lake Colungulac example, whilst for the N. S. Wales specimens he proposes the name *T. Oweni*, M'Coy.

Five species of *Trilobites* are figured, including *Phacops caudatus*, Brong., and *Homalonotus Harrisoni*, M'Coy. The former is one of our most typical Upper Silurian species, and appears to run through as many varieties, at the Antipodes, as in Britain. The latter is a representative of its English and American ally, *H. delphinocephalus*, Green.

Passing to fossils of Tertiary age, we are introduced to the Australian analogue of another British shell, *Nautilus* (*Aturia*) *zic-zac*, Sow., of the London-clay. The Victorian individuals from the Oligocene and Pliocene beds of Port Philip Bay so closely resemble the compressed variety of the above species (*Nautilus aturia*, Basterot), that Prof. M'Coy has merely given to them the varietal name *Australis* (*N.* (*Aturia*) *zic-zac*, Sow., var. *Australis*, M'Coy). Of numerous genera which have almost disappeared since the close of the Mesozoic Epoch is the genus *Pleurotomaria*. It is represented in European Tertiary strata by two rare species, *P. Sismondai*, Goldf., and *P. concava*, Deshayes, and in the living state by two still rarer, *P. Adansoniana*, and *P. Quoyana*. To these Prof. M'Coy has had the extreme good fortune to add a third Tertiary species, *P. Tertiaria*, from a limestone interstratified with Basalt on the Moorabool River, at Maud.

Prof. M'Coy has already made known two Tertiary species of *Trigonia* (*T. semiundulata*, M'Coy, and *T. acuticostata*, M'Coy), and now adds another, *T. Howitti*, a larger, thicker, and stronger shell than either of the former or the living species. It was found in sandy marl at the entrance to the Gippsland Lakes.

Two other forms call for special notice, one, *Cucullæa Corioensis* M'Coy, a very common shell in certain of the Victorian Tertiary beds. It is distinguished from the recent species by its much greater gibbosity, thicker shell, etc., and has for nearest allies in the fossil state a New Zealand Tertiary species, *C. ponderosa*, Hutton, and *C. crassatina*, Lamk., of the French Upper Eocene. The second form to which we would draw attention is the *Cypræa avellanoides*, M'Coy, an almost exact representative of the European *Trivia avellana*. Numerous other species are described to which less general interest is attached, although each forms a welcome addition to Australian Palæontology. R. E. Jun.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.—I.—May 10, 1876.—Prof. P. Martin Duncan, M.B., F.R.S., President, in the Chair. The following communications were read:—

1. "On some Fossil Reef-building Corals from the Tertiary Deposits of Tasmania." By Prof P. Martin Duncan, M.B., F.R.S., President.

The species described by the author were *Heliastræa tasmaniensis*, sp. n., *Thamnastræa sera*, sp. n., and a second species of *Thamnastræa*. Both these genera are composed of reef-building corals, and the species here described undoubtedly belonged to that category. They required the natural conditions peculiar to Coral-reefs. The author noticed the facts as to the distribution of land and water in the Australian region in Lower Cainozoic times, which are revealed by the deposits belonging to that age, and indicated that although the insular distribution of the land may have been unfavourable to the growth of Coral-reefs, the existence of a suitable sea-temperature in the latitude of Tasmania is insufficiently explained. A single relic of the old reef-building Corals survives on the shores of Tasmania in the *Echinopora rosularia*, Lam., but all the other forms have died off. The coral isotherm would have to be 15° lat. south of its present position to enable reefs to flourish south of Cape Howe, and this could be caused only by a change in the arrangements of land and sea, and in the position of the polar axis. The author indicated the general arrangements of land which seemed to have prevailed, and noticed that at that period and even earlier the coral isotherm of 74° reached fully 25° north of its present position in the portion of the globe antipodean to Tasmania; but it would seem to require more than mere geographical changes to account for the existence of important reefs in western, central, and southern Europe and in Tasmania synchronously. The flora underlying the marine Cainozoic deposits of Victoria indicate tropical conditions, as do the Echinodermata of the succeeding strata (described in the following paper). The fossil plants of the Arctic regions, from the Carboniferous to the Miocene epoch, give evidence of the existence of higher temperatures and of other conditions of light than those now prevailing; but were the polar axis at right angles to the plane of the ecliptic, and were there no greater node than at present, there would be equal day and night at all points. The difficulty is to account for the present position of the axis on this supposition; but the author suggested that the great subsidences of Miocene lands, the formation of the southern ocean, and the vast upheavals of northern areas at the close of the Miocene epoch, may have sufficed to produce the present condition of things.

2. "On the Echinodermata of the Australian Cainozoic (Tertiary) Deposits." By Prof. P. Martin Duncan, M.B., F.R.S., President.

In this paper, after noticing the history of our knowledge of Australian Tertiary Echinida, the author gave a list of the species at present known, amounting in all to 23, and described the following as new species:—*Leiocidaris australiæ*, *Temnechinus lineatus*, *Arachnoides Loveni*, *A. elongatus*, *Rhynchopygus dysasteroides*, *Echinobrissus australiæ*, *Holaster australiæ*, *Maretia anomala*, *Eupatagus rotundus*, and *E. Laubei*. The author remarked upon the characters and synonymy of the previously known species, his most important statement being that the so-called genus *Hemipatagus* is in reality identical with the recent genus *Lovenia*, Gray, as clearly shown by fine specimens in his possession. The most marked genera of the existing Australian fauna are not represented, but are replaced by numerous Spatangoids; three species, however, are identical; but two of these have a very wide range. Of the remainder, 9 are allied to recent Australian species, mostly from the north of the continent; 6 are allied to European and Asiatic Cretaceous forms; 5 are closely related to Nummulitic types; and one species appears to belong to a peculiar genus, namely, *Paradoxechinus novus*, Laube.

3. "On the Miocene Fossils of Haiti." By R. J. Lechmere Guppy, Esq., F.L.S., F.G.S.

After referring to the literature of the subject, the author stated that his paper was founded to a great extent upon the examination of specimens in the Society's Museum. He gave a list of the described fossil shells of St. Domingo, with notes on their synonymy, and described as new the following species:—*Sigaretus excentricus, Cancellaria epistomifera, Murex cornurectus, Turbinellus ædificatus, Crypæa Gabbiana*, and *Phorus delectus*.

II.—May 24, 1876.—Professor P. Martin Duncan, M.B., F.R.S., President, in the Chair. The following communications were read:—

1. "On the Old Glaciers of the Northern Slope of the Swiss Alps." By Prof. Alphonse Favre, F.M.G.S.

The author illustrated his remarks by a map on a scale of $\frac{1}{250000}$, showing the space occupied by the old Swiss glaciers at the time of their greatest extension, and founded in part upon evidence obtained since 1867, when he, in conjunction with Prof. Studer and M. L. Soret, issued an "Appel aux Suisses" for the preservation of erratic blocks. He said that in existing glaciers two parts may be recognized,—an upper one, the reservoir or feeding glacier, and a lower one, the flowing glacier. Applying this division to the old glaciers, it appears that in the glaciers of the Rhone and Rhine the flowing glacier which occupied the plain had a surface nearly equal to that of the feeding glacier which was situated in the mountains. By means of several tables M. Favre showed the height attained by these glaciers, their thickness, the slope of their upper surface, etc., at various points in the Alps, the Jura, and Swabia, and deduced as the result of the comparison of these numbers:—1. that the Rhone glacier passed over several of the chains of the Jura, and that the ice covering these, far from being an obstacle to the extension of the glaciers of the Alps, actually reinforced them, and served them as *relays*, the glaciers of the Jura having carried far on the Alpine erratic blocks. 2. That the slopes of the upper surface were variable, and were null, or nearly so, over considerable spaces.

At the Calanda, near Coire, there are erratics which seem to be at a higher level than that attained by the glacier. This may be explained by the formation in the glacier of a sort of *eddy*, which would elevate the ice to a certain amount over a limited space.

During the greatest extension the Swiss glaciers came in contact with those of Central France near Lyons; they united with those of the Jura, the Black Forest, and the Austrian and Italian Alps; they stretched from the plain of the Po to that of the Danube; and further, for distances of 50 or 100 kilometres they nearly approached horizontality. Hence they resembled the glaciers of the interior of Greenland and Spitzbergen, so far as can be judged from the descriptions.

2. "Evidences of Theriodonts in Permian Deposits elsewhere than in South Africa." By Prof. R. Owen, C.B., F.R.S., F.G.S.

In this paper the author noticed some described Reptilia which he believes to belong to his order Theriodontia. In 1838 Kutorga described as probably mammalian the distal end of a humerus showing a perforation or canal above the inner condyle. The specimen was from the Permian of the western Oural, and Kutorga gave it the name of *Brithopus priscus*. Under the name of *Orthopus primævus* he described the proximal part of the humerus of the same species, perhaps of the same bone. There is thus evidence of an extinct reptile in the Permian deposits of the Oural, with a humerus showing the characters of the Theriodont Reptiles of the Karoo series of South Africa. The British Museum possesses a cast of the first-mentioned fragment, labelled by Krantz "*Eurosaurus uralensis*, H. von Meyer, *Brithopus priscus*, Kutorga." The genus *Eurosaurus* was founded in 1842 by Fischer von Waldheim upon some fragments of bone, including a humerus with a broad proximal end, as in Kutorga's *Orthopus;* and Fischer also noticed a humerus showing characters like those of Kutorga's *Brithopus*, from the same locality as the portion of a jaw described under the name of *Rhopalodon Wangenheimii*, Fischer, which contained nine molar teeth, with thick, pointed, subcompressed crowns, with trenchant and serrate borders. In 1858 H. von Meyer described a skull from the Permian of the Oural, under the name of *Mecosaurus uraliensis*, as a Labyrinthodont; and Eichwald referred this genus, with Kutorga's *Brithopus* and *Orthopus*, to Fischer's *Eurosaurus*. The author regarded *Mecosaurus* as truly Labyrinthodont; whilst the Permian forms constituting Kutorga's genus were referred to the Theriodont order. From the same locality as the above Kutorga describes *Syodon biarmicum* as probably a Pachyderm. Its teeth resemble those of *Cynodrakon*. Eichwald's *Deuterosaurus biarmicus* is founded upon the fore part of both upper and lower jaws of a Reptile, containing teeth with denticulate or crenulate trenchant borders, the canines being large, especially in the upper jaw. *Deuterosaurus* closely resembles *Cynodrakon*, and still more the *Lycosaurus* of the Karoo beds of the Sneewberg range. All the above are from the Permian beds of the Oural, and the author regards them as furnishing important evidence of the Palæozoic age of the Karoo series, in which the Theriodont Reptiles are best represented.

The author further noticed a Theriodont allied to *Lycosaurus* from a red sandstone, probably of Permian age, in Prince Edward Island. The remains include the left maxillary, premaxillary, and nasal bones; the teeth, implanted in distinct sockets, have sub-compressed, recurved, conical, pointed crowns, with minutely crenulated borders. The foremost tooth in the maxillary is a canine, and in other points the dentition shows Theriodont characters. This fossil has been described by Dr. Leidy under the name of *Bathygnathus borealis*.

Thus, supposing the affinities of the fossils from the Oural and Prince Edward Island to be correctly determined, the Reptilia distinguished by Mammalian characters are shown to have had a very wide range. Further, the author thinks that the Theriodont Reptiles of the Bristol Dolomitic Conglomerate may also prove to constitute a family in the Theriodont order.

The Earl of Enniskillen stated that when Prof. Agassiz first came to England, he employed Mr. Dinkel to draw the fossil fishes, and obtained the fine collection of drawings which was subsequently presented to the Geological Society by the late Earl of Ellesmere. By a special arrangement, Lord Enniskillen and Sir Philip Egerton paid for those drawings which were made from each other's collections, the drawings remaining their property. In this way Lord Enniskillen is the possessor of those drawings which were made for Professor Agassiz from Sir Philip Egerton's collection, and it was his intention to leave them by his will to the Geological Society in order that they might be added to the set already in the Society's possession. Owing to the almost total failure of his eyesight, the figures in Lord Enniskillen's possession are now quite useless to him, and he proposed to present them at once to the Society.

The President offered the thanks of the Society to Lord Enniskillen for his intended present, and at the same time gave expression to its regret at the cause of his Lordship's determination.

THE GEOLOGICAL SOCIETY OF STOCKHOLM.

(GEOLOGISKA FÖRENINGEN I STOCKHOLM.)

At the meeting of this Society, May 4, 1876, Dr. Th. Nordström exhibited and described a theodolite, constructed by the late Mr. Barthelson, for the purpose of mapping mines.

Dr. E. Svedmark gave an account of some microscopical researches on Uralite-porphyry from Vaksala near Upsala in Sweden.

Mr. E. Erdmann called attention to the power of the waves in denuding, grooving out and grinding rocks along the sea-shore, and exhibited a model, constructed by himself, showing the result of this power on the almost perpendicular layers of sandstone at the coast of the Firth of Forth, near Edinburgh, a place visited by him last year. He then exhibited some samples of sand, etc., from a deep boring at Gothenburg, in Sweden, where, at a depth of from 114 to 116 feet under the surface, and about 100 feet below the level of the sea, a shell-bed, or a bed of sand with many remains of shells, had been discovered. *Mytilus, Balanus, Yoldia* and Foraminifera were found. This shell-bed at so great a depth below the sea-level may perhaps indicate that the land here once, during or later than the Glacial Period, was higher than it is at present. He also exhibited some specimens of *jasper,* which Dr. A. G. Nathorst had found in Skåne (Scania) as small layers and lenticular masses in a sandstone, probably of Triassic age.

In reference to the account of Mr. Erdmann of the denuding power of the *waves, Prof.* O. Torell and Dr. Nordström drew attention to some places in Sweden where this denuding power also could be traced. Prof. Torell also mentioned the marine fauna at Gothenburg, and Mr. Börtzell made some remarks on the deep-boring at Gothenburg.

Geologiska Föreningens Förhandlingar. Stockholm. No. 32. Contents.

1. Meeting. April 2, 1876.
2. C. W. Blomstrand. Bidrag till kännedomen om Längbansgrufvans mineralier. (Contribution to the Knowledge of the Minerals of the Längban-mine in Sweden.)
3. A. M. Jeurström. Om Finlands postglaciala skalgrusbäddan. (On the Post-glacial Shell-beds in Finland.)
4. E. Erdmann. Profil genom en rullstensås. (Section of a Swedish "Ås"—Kames, Eskers—consisting of stratified sand and gravel with boulders.)
5. Swedish, Norwegian, Finlandic, and Danish geological literature published during 1875.

CORRESPONDENCE.

APPARENT AND TRUE DIP.

Sir,—Mr. Penning's very simple construction for direction of dip, given in the May Number of this Magazine, is only approximate, and in extreme cases might be rather widely wrong. In the case he has taken for his figure the error will be about 3°; in the case of dips of 30° and 60° at right angles to each other, his construction would be 8° wrong.

The accurate rule would be as follows:—

Draw two lines from a point in directions of the two observed dips. Set off along each line lengths proportional to the tangent of the other dip (or to the cotangent of its own). Join the ends of these lengths: the joining line will be the direction of the strike, the perpendicular to it from the angle will be the direction of the dip.

Moreover, if cotangents have been used, the *length* of this perpendicular is proportional to the cotangent of the true dip, whose magnitude as well as direction will thus be determined by one construction.

Mr. Penning's construction would give the magnitude of the dip by the formula: Length of perpendicular : length of a side :: dip in direction of *other* side : true dip. And as accurate values of dips are usually needless, this would probably give sufficiently correct results.

Mr. Penning's rule, as any one acquainted with Trigonometry may see, is equivalent to assuming that angles are proportional to their tangents.

E. Hill.

Cambridge, *May 23rd*, 1876.

SOUTH AUSTRALIAN POST-TERTIARY FORAMINIFERA AND OSTRACODA.

Sir,—A notice of the occurrence of the following species of Foraminifera and Ostracoda in the Post-Tertiary beds of South Australia may be of interest to some of your readers. A small collection of Mollusca was presented to the Museum of Practical Geology, London, many years ago, by Mr. H. Challoner, of the Burra-Burra Mines, South Australia. From the matrix contained in and surrounding these the minute fossils were washed by Mr. J. Bennie and myself.

According to the label accompanying the shells, they were found in sinking a Government well in the Murray River Flats, on the road from the Burra-Burra Mines to the Great Bend of the Murray River, about half way (thirty miles) between the two points named. For the determination of the Foraminifera I am much indebted to Mr. H. B. Brady, F.R.S., and to Prof. G. S. Brady, for a like examination of the Ostracoda.

The Foraminifera are—

Biloculina contraria, D'Orb.
„ *depressa*, D'Orb.
„ *elongata*, D'Orb.
„ *ringens*, Lamk.
Cornuspira foliacea, Phil.
„ *involvens*, Reuss.
Cristellaria rotulata, Lamk.
Glandulina lævigata, D'Orb.
Hauerina compressa, D'Orb.
Orbitolites complanatus, Lamk.
Planorbulina reticulata, Czjzck.
„ *Ungeriana*, D'Orb.
Polystomella craticulata, F. & M.
„ *macella*, F. & M.
Pulvinulina elegans, D'Orb.
Quinqueloculina agglutinans, D'Orb.
„ *secans*, D'Orb.
„ *seminulum*, Linn. (var.)
„ *subrotunda*, Montagu.
Rotalia Soldanii, D'Orb.
Spiroloculina canaliculata, D'Orb.
Triloculina oblonga, Montg.
„ *tricarinata*, D'Orb.
Truncatulina lobatula, W. & J.

The Ostracoda are—

Bairdia ovata, G. Brady.
Macrocypris acuminata, Reuss.
Cythere Normani, G. Brady.
Paracypris decora, G. Brady.

Prof. Brady remarks that these appear to be perfectly identical with the Ostracodal fauna now living in the seas of Australia and the Malay Archipelago. A few other Ostracoda were also present, probably new; but from the paucity of individuals it was scarcely advisable to describe them at present.

The Murray River Flats consist of a flat scrubby plain extending from the Murray River on the East, between the Great Bend and Lake Victoria, to the South Australian Chain, or Cape Jervis Range, on the West, and must be composed of strata, geologically speaking, of no great antiquity; in fact, the whole of that portion of the southern coast of Australia bears evident traces of recent upheaval, even in places now going on.

R. ETHERIDGE, Jun.

EDINBURGH, *May*, 1876.

LLANDOVERY ROCKS IN THE LAKE DISTRICT.

SIR,—The assertion made by Mr. Aveline in the last Number of the GEOL. MAG., that "both the Upper and Lower Llandovery Rocks are absent in the Lake District," is not borne out by the researches of other observers, nor is it in accordance with the published statements of such well-known authorities as Prof. Harkness and Dr. Nicholson. The Coniston Limestone is generally acknowledged to be the equivalent of the Bala Limestone, and the succession up to this point is quite clear. Upon this limestone the Graptolitic Mudstones, according to Mr. Aveline, rest "with a very slight unconformity," and he considers the mudstones to be the equivalents of the Tarannon shales of Wales. The Tarannon shales he considers form the base of the Wenlock series, and hence to be higher in the scale than the Upper Llandovery or May Hill sandstones. Now, by a strange coincidence, we find the following statement by Dr.

Nicholson in the same Number of the MAGAZINE, p. 246:—"It is highly satisfactory to me to know that Dr. Linnarsson's investigations fully corroborate the view always maintained by Prof. Harkness and myself on this matter—namely, that the Coniston Mudstones are indubitably inferior to the true Upper Silurian rocks." In the same paper he mentions several facts in support of this view, and I certainly think the evidence at present tends strongly to show that these mudstones are considerably lower in the succession than Mr. Aveline would have us believe. The Coniston mudstones, flags, and grits collectively appear to represent the Upper and Lower Llandovery rocks of part of Wales, and probably also the Tarannon shales and Denbighshire grits. These latter are not, in my opinion, to be placed altogether above the Llandovery rocks, but to a great extent to be considered their equivalents. That difficulties will continually arise in any attempt that is made to correlate these rocks in different districts there can be no doubt, and the reason is obvious when we recollect how great the changes were which took place at the time these were deposited. In the May Number of the GEOL. MAG., pages 215 and 216, I attempted to explain what the result of necessity would be in those areas which were undergoing these great physical changes, and the effect on the deposits, and the order of succession. It is tolerably clear that the uplifting of the sea-bottom in Cumberland, and in North Wales, occurred after the Upper Bala and Coniston Limestone had been deposited, for the succession is perfectly clear in both areas up to that point. The uplifting which now occurred raised the sea-bottom above water-level in parts of those areas only, and to unequal heights. Hence portions remained submerged, some became shore-lines and shallows, and others were raised sufficiently to become dry land. It is clear, therefore, that as these parts were again gradually submerged, sediments were laid down more or less unconformably upon the uplifted portions, and that the character of the sediments and the thicknesses would vary greatly even within very narrow limits. The denudation of these uplifted portions would also furnish abundant material, and so the sediments would be heaped up rapidly in the surrounding sea. In the Welsh area the Lower and Upper Llandovery rocks of South Wales were heaped up at this time, and as this part continued under water during the whole period, the sediments there show perfect conformability throughout. But as we advance nearer towards the uplifted portions, the series gradually thin out, and an unconformity may show itself at almost every point in the succession up to near the close of the Upper Silurian. The Tarannon shales of the extreme North of Denbighshire and the Denbighshire grits, being entirely the result of the denudation of these islands, were also heaped up chiefly at the time the Llandovery rocks were deposited in South Wales; consequently, for the most part they may be correlated with them. The same order in the deposits appears to be shown in Cumberland, and I entertain no doubt but that at some part of that area the same general succession may be recognized.

HERIOT HOUSE, HENDON. HENRY HICKS.

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ORIGINAL ARTICLES.

I.—Contributions to the Study of Volcanos.—Second Series.

By John W. Judd, F.G.S.

On the Interval which separated the two great Periods of Volcanic Activity in Connexion with the Formation of the Alpine System.

THE study of the great mountain ranges of America by Rogers, Hall, Dana, Le Conte, Hunt, and other geologists, has now thrown much new light on the earth-movements which precede and accompany the formation of mountain chains. As the result of these researches, it appears certain that the preliminary stage in the formation of every mountain system has consisted in a long-continued depression of the area which is afterwards to become its site; and, in consequence of this prolonged subsidence, the accumulation of an enormous thickness of stratified rocks, within the great trough so formed, has taken place. Of this character, as is now well known, have been the earlier manifestations of the subterranean forces that were concerned in the formation of the Appalachians, Green Mountains, and other American ranges; the districts in which they are situated were subjected to long-continued depression, which permitted of an abnormal development of all the members of the sedimentary deposits formed during this initiatory period; and it was by the folding, metamorphism and crushing together of this abnormally thickened portion of the earth's crust that the indurated and elevated masses have been formed which denudation has sculptured into the existing mountain chains.

Now of the occurrence of just such long-continued periods of subsidence as constituted the earlier stages of the formation of the American mountain systems, we have very clear and unmistakable evidence in the case of the Alps. After the series of volcanic outbursts, which we have described in detail in our last chapter,[1] as indicating the existence of the Alpine line of weakness, a period of almost uninterrupted, though irregular, subsidence of this portion of the earth's crust commenced, and was continued throughout the epochs of the Upper Trias, Rhætic, Jurassic, Tithonian, Neocomian, Cretaceous and Nummulitic formations.

In proof of this prolonged and continuous depression in the Alpine region, we may appeal to a number of well-known geological facts. In the first place, it must be remarked that almost every member of the Mesozoic and older Eocene formations has attained in the Alpine regions its maximum of thickness and development. Secondly, we must bear in mind that of the periods which in surrounding districts are totally unrepresented by sedimentary deposits (indicating that these areas were not, during the periods in question, subjected to depression, but rather, as shown by numerous and marked unconformities, were the scenes of elevation and denudation) we find in the same Alpine regions most important and interesting representatives. Thus the Trias, which over so large a part of Northern Europe exhibits evidences only of the prevalence of terrestrial and lacustrine conditions, is represented in the Alps by an enormous thickness of strata, crowded with the forms of marine life of the period. The Rhætic, which finds so inadequate a development in other parts of Europe, is in the Alps a grand formation several thousands of feet in thickness, which completely bridges over the interval between the Triassic and Jurassic. Similarly, the great break which in other areas exists between the Jurassic and Neocomian, and is so often marked by strong unconformity, or the prevalence of land surfaces and lacustrine deposits, does not exist in Alpine regions; but on the contrary a formation, not unfrequently thousands of feet in thickness, and yielding an interesting fauna of intermediate character, links the two together; so that the transitions from Jurassic to Tithonian, and from Tithonian to Neocomian, are alike imperceptible. Even the very general unconformity at the base of the Cretaceous finds no place in some parts of the Alpine area, for highly fossiliferous deposits unite the highest members of the Neocomian with the oldest beds of the Cretaceous. Lastly, even the greatest gap of all, that between the Mesozoic and Tertiary deposits, is found to be bridged over in the Alps; and in the midst of the thick masses of the Vienna and Carpathian sandstones it is impossible to draw lines that may serve to divide these elsewhere distinctly separated periods. In short, in the Alpine districts we seem to have clear proof that from the commencement of the Triassic to the close of the Nummulitic period continual subsidence, attended by constant deposition, was going on, and that the interruptions or reversals of this movement were only local and partial, and unattended with any wide-spread effects.

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[1] See the May Number, p. 200.

Still another confirmation of the same series of movements may be found in the diversities between the faunas of the North and South of Europe during the Mesozoic periods,—diversities which are incapable of being accounted for by any differences in climatal conditions. While on the one hand it is demonstrable that no ridge of land existed which during these periods served to separate these distinctly marked life-provinces, we may point out the same effect would have been produced by the presence of a great and constantly depressed or deep-water area, such as we know existed during the whole of these epochs in the Alpine region.

As shown by Mr. Darwin, the existing areas of depression within the tropical and sub-tropical portions of the earth's surface are often marked by the growth of coral-reefs; and that the same was the case during the long periods of subsidence of the Alpine regions is *clearly* proved by the studies of Richthofen, Mojsissovics, and numerous other observers. Vast masses of limestone, sometimes thousands of feet in thickness, and not unfrequently wholly or in part converted into dolomite, stand in the midst of the sedimentary deposits of different age in the Alpine regions; and the nature of the organic remains of which these are built up leaves no room for doubt that they represent the enormous coral-reefs of this old period of subsidence.[1] At the present day, denudation having swept from their sides the masses of sediment by which they were surrounded and embedded, these calcareous and often dolomitized pinnacles stand in isolated grandeur, constituting some of the most striking scenery of our continent.

To refer once more to the results of Darwin's researches on the changes taking place on the globe at the present day, we may point out that he has shown how areas of depression are characterized by the non-appearance of volcanic action within them; and it is interesting to find that, during the prolonged periods of depression in the Alpine area, we have very few, if any, indications of the occurrence of volcanic outbursts within it. In the limestone area of the Tyrol and Salzkammergut, it is true that a few intrusive masses of gabbro, serpentine and other rocks have been noticed; but they are in every instance, so far as I am aware, unaccompanied by any appearances which would indicate that these igneous masses had ever reached the surface and produced volcanic action there. Indeed, it may be asserted as a matter of fact that the Mesozoic period was, throughout Central Europe, marked by an almost total cessation of volcanic activity; although in the eastern portions of Europe, as in the Carpathians and Greece, small and scattered igneous outbursts would appear to have taken place in the Liassic and Cretaceous periods.

According to Dana, the "geosynclinal" or downward bending of the earth's crust, the formation of which was the first stage in the origin of the Appalachian chain, began in or before the Cambrian period, and did not close till after the completion of the Carboniferous; and during this interval a mass of strata, which at its thickest part could not have been less than 40,000 feet or eight miles in thickness, was formed. Similarly the "geosynclinal" of the Alps, of which the formation appears to have been going on during the whole interval between the commencement of the Trias and the end of the Nummulitic, seems to have led to the accumulation of a mass of strata having an aggregate thickness which probably is scarcely, if at all, inferior to that exposed in the Appalachians.

It is evident that this downward bending of the crust, of which we have so many clear examples in mountain ranges situated at different parts of the earth's surface, could not go on indefinitely. Even if no fresh causes were brought into action, the time must come when the lateral thrusts, which had produced so striking an effect in the downward fold along the line of weakness, must have given rise to a crumpling or crushing together of the rock masses along this same line, rather than to its simple depression in a downward curve.

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[1] See Review of Gilbert's and Churchill's Dolomite Mountains (by the late Dr. S. P. Woodward), *Geol. Mag. 1864,* Vol I. p. 40.—Edit. Geol. Mag.

But as a matter of fact a number of new forces would be called into operation by the enormous depression and accumulation of sediments along these geosynclinal lines. At a depth of 40,000 feet, taking the average increase of temperature as determined in mines, bore-holes, etc., as our guide, we may infer the existence of temperature capable of producing a decided red heat, and doubtless sufficient to permit of the imprisoned water and other substances, acting during enormous periods, effecting the most striking metamorphic changes. But this is not all. The softening plastic mass thus produced, yielding to the enormous lateral pressure, would be folded and crushed together, and, as has been shown by Sorby and Hunt, the mechanical force where opposed might be transformed into chemical; and thus fresh energy would be communicated to those operations whereby new crystalline products were being formed from the sedimentary masses. Still another cause must be added in the heat produced by the transformation of the crushing forces, as shown by Wurtz, Vose, and Mallet. From all these causes combined, the thickened mass of sediments of the geosynclinal, especially in their lower portion, would be folded and crumpled and at the same time subjected to such an amount of internal chemical action, as would permit of the elements of which they are composed arranging themselves into crystalline minerals, according to their several affinities, under the peculiar conditions of pressure and temperature.

This breaking up of the geosynclinal, resulting from continued subsidence along a line of weakness, has sometimes been spoken of as resulting in a *catastrophe*, when the mass, weakened by accessions of heat, first began to collapse. But it is perhaps very doubtful if any such marked cataclysmic effect would ever be produced. It is at least equally allowable to suppose, that as each inferior stratum came within the influence of the metamorphic action, and, acquiring plasticity, yielded to the lateral or tangential strain, it would become folded on itself, and thereby tend to neutralize the subsiding movement of the overlying masses. Thus there would be set up two opposing tendencies in the great thickened mass, and in the end the upward strain resulting from the folding together and crumpling of the lower strata would gradually neutralize and finally overcome the downward bending, the cause of the great subsidence, which was the first effect of the lateral pressure.

When this point was arrived at, the long-continued downward movement in the Alpine region would be brought to a close, and in the end reversed. And as a fact we find during the period of the Oligocene the evidence of just such a pause and gradual reversal in the movements which had been going on in the Alpine and surrounding districts. The accumulations of thick masses of marine strata, indicative usually of a considerable depth of water, gradually ceased; littoral, brackish-water, and finally lacustrine and terrestrial deposits succeeding them. That the subsiding movements were still *locally* maintained, while the *general* tendency was towards a movement of elevation, is shown by the great thickness of terrestrial, lacustrine or estuarine deposits accumulated at certain points, and which contain the valuable masses of fuel so characteristic of the formations of this period. The effects produced by the conflicting action of movements of opposite character, resulting from the gradual breaking up and destruction of the great Alpine *geosynclinal*, appear to me to be just such as would result in the formation of those vast lakes, either connected with or entirely separated from the sea, which characterize the Oligocene period. Such lakes, by the accumulation of sediments in them, would be converted into alluvial plains, that, after supporting luxuriant forests or vast peat-mosses, appear to have been again depressed and re-converted into receptacles for sedimentary deposits; the same operation being repeated again and again through a thickness of thousands of feet, as is illustrated by the basins of Brown Coal in Northern Germany, and the equally vast Coal-basins of the Oligocene period in Eastern Europe. The duration of this well-sustained conflict between the tendencies towards depression and upheaval respectively must have been enormous, as shown alike by the thickness of the deposits formed at certain points during the interval, and by the changes undergone both by the molluscan and mammalian faunas between its commencement and termination. That the conflict terminated finally in the triumph of the tendencies towards elevation is sufficiently proved by the vast increase in the extent of the land area which certainly existed during the next succeeding period, that of the Miocene. Thus it is clear that the lateral thrust to which the thickened masses of sediments of the Alpine line of weakness had been so long subjected resulted, towards the close of the Oligocene period, in a marked and general *elevatory* movement, succeeding to the subsidences of the Secondary and Eocene periods, and the oscillatory effects of the earlier Oligocene.

No fact is now more familiar to geologists than that the areas of the earth's surface in which active volcanic vents exist are usually subject to elevatory movements; and it is interesting to find the converse of this proposition very strikingly illustrated in the ancient geological history of the Alpine system. No sooner do we detect the symptoms of the long-continued movements of subsidence being gradually brought to a close, than we also begin to notice the first symptoms of the renewed outburst of volcanic forces, in the regions where, as we have before seen, they had been so long quiescent. And, as the elevatory tendencies gradually gathered strength and force, and finally overcame the prolonged downward movements, so we find the volcanic outbursts increasing in number and violence. Till at last, at the very period when we detect in the whole Alpine system unmistakable evidences of upheaving movements on the most stupendous scale, we also observe in the whole of the surrounding areas the clearest proof that volcanic outbursts of the most tremendous violence were taking place contemporaneously, and building up cones of prodigious dimensions. Finally, when towards the close of the Miocene, and through the long periods of the Pliocene on to the present day, the movements of the central Alpine masses became less rapid and violent, we find the volcanic manifestations in the surrounding areas simultaneously declining in energy, the vast central volcanos becoming extinct, and the dying igneous forces only making themselves felt in long trains of "puys," and finally in hot springs and gaseous exhalations. But the volcanic commotion around the Alpine system has not yet wholly subsided, and it may be regarded as almost equally certain that the oscillatory movements of the central mountain masses are not even yet altogether exhausted.

We have seen how the first existence of a line of weakness in the earth's crust, along what was to be the site of the future Alpine chain, was betrayed by the volcanic outbursts of the Permian and Triassic periods. It might at first sight appear that the renewal of volcanic violence in the middle of the Tertiary period would take place on the same line. But when we reflect on the enormous thickening of the crust which had been effected along this line, owing to the formation of the geosynclinal and the accumulation of such an enormous mass of sediments, as well as on the strengthening of that part of it by its being crumpled together and converted into crystalline rock, it will be clear that the lines of weakness liable to yield to the volcanic forces, and so to produce eruptive fissures, will no longer be situated in the axis of the *synclinorium* (as Dana calls the crushed and upheaving *geosynclinal*), but rather at lines of junction of this thickened and strengthened mass with the surrounding normally developed series of stratified rocks.

Now it is just at such points, and indeed all around the central masses of the Alps, and of its several ramifying chains, that the volcanic action of which we have spoken has been manifested. It would require a treatise to describe the varying manifestations, the history of the gradual appearance, of the attainment of its grand climax of violence, and of the slow decline and gradual extinction of this belt of fire which surrounded the Alpine system during the period of its great and final stage of upheaval. In the concluding chapter of this series we shall not be able to attempt more than to sketch in its barest outlines the main features of this remarkable history.

On one point, however, we turn to this history with particular interest, for in it, if anywhere, the geologist may perhaps hope to find the solution of a problem of the highest importance. I allude to the question as to what are the characters of the initiatory stages of the manifestations of volcanic violence in a district. The age of man, or even the duration of human history, is as nothing in comparison with those periods with which the geologist is called upon to deal. By direct observation we can accomplish nothing, for even the smallest cycles of geological change are not completed within the periods dealt with by our limited experience or contracted records. Doubtless in some parts of the globe the seeds of the volcanic disease in the earth's crust are even now beginning to make themselves felt by premonitory symptoms; but how are we to recognize these as such, seeing that we shall not live to witness the climax of the attack? It is clear that our only hope of learning the nature and characteristics of the first symptoms of a volcanic outbreak on any part of the earth's surface, is by studying the whole history of a volcanic outburst from its commencement to its close, by examining the record of the rocks with the aid of the palæontological scheme of chronology. But here the investigator finds himself beset with another difficulty. The violent and destructive effects of the later and grander periods of eruption having sufficed to obliterate, in too many instances, almost every trace of the products of the earlier and feebler manifestations of volcanic action.

One conclusion on the subject we may now, however, regard as being sufficiently well established; namely, that the first appearance of volcanic action in a district is usually, if not always, of a gradual character, and that it is preceded by a series of phenomena, similar in character, but taking place in a reverse order to those which accompany the decline of volcanic forces in any area. In the Auvergne, and the Euganean Hills, in Hungary, and Bohemia, and indeed in all the old volcanic districts surrounding the Alpine system, we find sufficiently clear proofs that the close of the long period of the cessation of volcanic violence in the area was heralded by the appearance of springs containing large quantities of carbonic acid, or holding silica and other substances in solution; then of similar springs with an elevated temperature, and of sources of heated vapour and acid gases; eventually actual fissures were formed, giving rise to the formation of cinder-cones and lava-streams of insignificant dimensions (like "the puys"); till, gathering fresh force, the igneous activity was in the end equal to the task of building up the largest volcanic cones, and these became the seats of paroxysmal or long-continued outbursts on the grandest scale. Such a history appears to belong to all the centres of volcanic forces around the Alpine system, from the first premonitory symptoms in the Oligocene to their climax in the Miocene.

In the present chapter we have had such frequent occasion to speak of the tremendous efforts of elevatory or igneous forces, that we may possibly be misunderstood as referring the actual *forms* of mountain masses to such causes. Nothing could, however, be possibly further from our intention. The existing surfaces of the Alps we regard as being entirely the result of the sculpturing action of denuding forces. In three different ways, however, have the subterranean forces contributed towards the formation of this and other great mountain systems. *First*, by leading to the abnormal thickening of the earth's crust along a certain line. *Secondly*, by folding and crumpling together this thickened mass, and producing from it a crystalline axis, capable of withstanding the action of denuding forces to a much greater extent than the surrounding unaltered masses. *Thirdly*, by elevating the masses into regions of the atmosphere in which the destructive effects of moisture, frost and heat, and the transporting powers of water and ice act with their maximum intensity. That during the great movements, lines of weakness have been produced, and fresh lines of drainage originated or old ones modified, and thus the action of denudation greatly controlled, we are far from denying; but we regard all these actions as exercising only a subordinate effect in producing the actual forms of the Alpine masses.

Of the last grand elevation of the masses of crumpled and crystallized sediments, out of which the Alpine peaks and valleys have been sculptured, we have apparently a striking proof in the former prevalence of glaciers of enormous extent, descending from them into the plains around. Some have seen in these indications only the evidences of a former period of intense cold, or even of a succession of such periods. But if we consider that one of the main requirements for the production of vast glaciers is the existence of a large area of precipitation above the snow-line of the district, we shall be led to conclude that the upheaval of the gigantic Alpine masses during the Miocene would be just such a cause as would produce the phenomena in question. And as the broad ridge was gradually eaten away on either side, in the manner so graphically described by Dr. Hector as having taken place in New Zealand—atmospheric forces crumbling the storm-beaten rocks, while the ever-descending glacier bore the detritus into the valleys, thus constantly exposing fresh surfaces—the great continuous plateau would gradually be broken up and assume the form of isolated peaks and ridges, separated by valleys. Finally, as the gathering grounds of the Alpine snows were gradually reduced in extent, the glaciers which they fed would also be diminished, and the transporting power of running water be substituted for that of moving ice.

The deposits on the lower lying tracts around the Alps certainly point rather to the existence of a tropical or sub-tropical district, into which glaciers bearing transported blocks were protruded, owing to the existence of a large area in the vicinity above the snow-line, than to that constant change of temperature of the whole hemisphere, which some have argued for, but which is negatived by so much palæontological evidence. The great point which is constantly lost sight of by these theorists is that the *existence of glacial conditions is no proof whatever of a reduced temperature in a district,* but only of the presence in the neighbourhood of a large extent of land subject to great precipitation of moisture above the snow-line. In New Zealand and South America the rocks are being scored and striated, and accumulations of glacial detritus are being formed in the midst of a district covered with tree-ferns and surrounded by a tropical or sub-tropical fauna and flora; and in the Jurassic period a similar state of things prevailed in our own islands. That the peculiarities of the deposits of the Miocene and subsequent periods which surround the Alps are much more easily accounted for by the phenomena we have alluded to, rather than by invoking the aid of great secular changes in the climate of the globe, due to very questionable astronomical causes, most geologists will be prepared to admit; though of course changes of climate due to the different distribution of land and water, and perhaps also to other causes less perfectly understood, would certainly have had a place in the Alpine as well as in other districts.

That the earth's crust presents evidence; as Prof. Suess has so well shown, of large areas which during long geological periods have been subjected to similar movements—which tracts are, however, separated by lines of weakness—few geologists will now be prepared to dispute. And it is to the efforts of nature to repair these lines of weakness that the formation of mountain chains must be referred. The mass of folded, crumpled and crystallized rocks formed out of the abnormally thickened strata may indeed be compared to the cicatrix produced by the reparative vital actions around a severe wound; and we may perhaps go a step further, and regard the volcanic ejections around it as equivalent to the suppuration and discharge which accompanies the determination of the vital energy towards the injured part. May we not even consider this power of repairing external injuries as not less essential to the continued existence of the globe, than it is to the life of the organized beings which exist upon its surface?

II.—ICE AND ICE-WORK IN NEWFOUNDLAND.

By JOHN MILNE, F.G.S.,

Professor of Geology in the Imperial Mining College, Tokei, Japan.

(*Continued from the July Number*, p. 308.)

Aspect of Newfoundland.—It has been suggested that the so-called glacial effects which are universally seen in temperate, and even in tropical regions, may in many cases have been due to an ocean on which great icebergs floated. These, as they moved from point to point (like huge pepper-castors), strewed broadcast boulders and detrital matter, such as are now to be seen over an area like that of Russia and parts of North America. The effect of the force of impact of these tremendous masses has also been dwelt on, and the way in which they could grind, smooth down, or rub up the surface of a submerged area, has also often been referred to.

Should the area thus acted on be a rising one, on its emergence it may show definitely the characters that have been impressed upon it, and these perhaps may in some respects be analogous to those produced by land ice. In the explanation of the superficial aspects of a country from some such considerations as these, one man may take his stand upon a glacier, and another upon an iceberg. An iceberg theory has been advanced in the case of Newfoundland as an explanation of the physical features of the island (see Quart. Journ. Geol. Soc., 1874, vol. xxx. p. 722). From the numerous raised beaches containing *Mya arenaria* and other Atlantic species still living in the surrounding seas, Newfoundland appears to have risen in later geological times. The island itself, its principal bays, its mountains, its lakes and rivers, its lines of igneous protrusions, its ice-grooves and scratches, and the general strike of the rocks, which, as was shown by Jukes, may in part account for the tendencies of the other features, have all been shown to trend from about 27° E. of North to 27° W. of South.

These curious coincidences were in part explained by supposing Newfoundland as a rising area submerged 3000 feet beneath its present level, and some denuding agent like the present Arctic current with its load of icebergs passing over it. This theory, I believe, is looked upon as being considerably strengthened by observations over a large part of North-east America. With regard to the Newfoundland portion of the Western Continent, I wish to show that it is not so clearly to be demonstrated.

After watching several icebergs grounding, it appears to me that they would tend to give anything but a parallelism in their abrading action.

An iceberg aground slowly lurches and rolls, and turns from side to side, as it is differently affected by the wind, the tide, or a current, evidently tearing up and grinding in several directions the strata on which it rests.

To conceive the method in which icebergs acted to form the "parallelism of features," as seen in Newfoundland, a picture must be drawn, which I am afraid will hardly be taken as the true one. As the island rises, the lines of valleys and of the hills have been formed, and along these troughs, and by the ridges, the icebergs pass. This initial direction may, amongst other causes, be due to the configuration of pre-existing land, to the general direction in which detrital matter is strewn by an ocean current. Whilst the land is still beneath the surface of the water, we must imagine these huge islands of ice tripping along from hill-top to hill-top, sometimes just grazing the sides of a submerged valley, and sometimes scouring the surface of a hill, like butterflies before a breeze which try to stop at every tempting flower.

That they may have scattered the boulders which are to be found in most parts covering Newfoundland does not appear to be so great an impossibility as that they were the originators of the parallelisms; but even these, from the observations made by myself and my companion, the late Mr. T. G. B. Lloyd, F.G.S., during the summer of 1874, it appears to me that they might be ascribed to another origin.

Ice-Marks in Newfoundland.—On the eastern coast of Newfoundland, from the extreme South to Kirpon on the North, a distance of 300 miles, boulders and other indications of ice-action are to be seen in most parts: reference to them has been made in the Quart. Journ. Geol. Soc., London, 1874, vol. xxx., p. 725. Near St. John's, ice-grooves and scratches are to be seen up to considerable heights, whilst drift with well-marked stones cover the country. The narrow neck of land that separates the Bays of Trinity and Placentia affords considerable evidence of ice-work. Standing on the water-parting which divides the streams into one of these bays from those entering the other, the contour of the country, which is typical of many other parts of Newfoundland, may easily be viewed. All around is a rough brown surface of berry-bearing bushes and stunted spruce, dotted here and there, over which there are small soft green marshes. These latter generally form the border to many a quiet pool, the dark surface of which seems only to be made as a reflector for a passing cloud or some bare ice-marked hummock, a few of which rise here and there, forming undulations in the surrounding level. In such places as this the rivers of Newfoundland have their source. Looking down the valley towards one of the bays, your eye wanders over a flat-topped expanse of spruce and other underwood, through which a few scattered pine-trees sometimes lift their heads. To the right and left of this dark mass of stunted underwood there is a line of scarp-faced hills, which look as though they might once have been feeders of moraine to a glacier which, as it slowly pressed itself downwards, ground against their sides. Above the cliffs along the sky-line of the hills, a few large boulders are distinctly visible. On climbing to the top of these hills, you would see beneath your feet a chain of lakes and ponds dotted in amongst the trees. Each of these would have its fringing of green marsh, across which a dark line showing the trampled path of the wandering 'Cariboo' would be well marked. Connecting these lakes in their upper portions are a series of rapids and small waterfalls; whilst lower down, as we approach the tideway, there are often long 'reaches' of steady water. Further north, similar signs are visible,—in Bonavista Bay, in Green Bay, and in many others.

In Green Bay, or, as it is sometimes called, "the Bay of Notre Dame," on the highlands above Belt's Cove, the country, for many miles in extent, is thickly strewn with boulders.

The climb up to this boulder-land (which on the side next the sea forms steep cliffs) is a precipitous one; on reaching the top you are on a brown-looking country in the main undulating as if ice-worn. In the depressions there are either small ponds or marshes, which are bounded by bare hummocks. Sometimes a small cliff-like scarp looks down upon you from still higher ground. The boulders are strewn everywhere, but more particularly upon the highest ground, and often upon extreme points. Several boulders were so perched on two points that they formed an archway beneath, which could be seen at a distance of several miles. In another case one boulder was seen resting upon another. In form they were sub-angular. Fragments were taken from these, and also from boulders in several other districts, and, so far as my examination went, I found that, if not represented by the rock of the surrounding country, they had representatives further west, and this generally in the Laurentian granites. Mr. Alexander Murray, F.G.S., of the Geological Survey, has made the same observation. Now if these boulders had been deposited by Icebergs, this portion of Newfoundland must at the very least have been 1000 feet lower than it stands at present. During the time of its elevation, and especially at the time of its emergence, these boulders must have been subjected to a considerable amount of rough usage, and have received many rolls. If they were protected by a covering of drift, which, to secure them from the action of the sea, must have been many hundreds of feet in thickness, then the surface-configuration of the country might be difficult to be accounted for. Rough treatment, such as boulders receive upon a beach, would hardly have relinquished them in their present subangular condition, nor would it have left them upon the highest ridges, or poised them them upon a peak, or perched them one upon another. On the other hand, I think it would rather have tended to smoothen them down and deposit them in heaped confusion in the valleys, and they would probably, in that case, have been derived from the North-East rather than from the West, as they seem to indicate. Let alone the mechanical forces, which are constantly at work upon a beach, the ordinary processes of disintegration, the result of subaerial conditions must have exercised considerable influence during the ages that have elapsed, whilst the land was rising to its present elevation, and this especially upon such soft rocks as serpentine, of which many of these erratics consist. Such boulders as these seem to point to another origin rather than to that of a sea full of icebergs.

Further to the north the same circumstances are here and there presented. Sailing up the long straight shore of White Bay, a line of hills, whose topmost heights are fringed with boulders, are seen trending away before you to the northward, until their escarpment which faces the Atlantic grows dim, and is lost to view in the distance. After the red cliffs of Conche (which are almost the only fragment of Devonian Shale in Newfoundland) have been passed, Kirpon, the most northern settlement in the island, is reached. Boulders are to be found here, and some of them of immense size.

Western Newfoundland.—After leaving Kirpon, we pass the northern end of the long range of granitic hills, running parallel with the western coast, forming the great backbone of the country, and which give to it, in some respects, a contour not unlike that of Arabia, the slope leading to the eastern coast being flat and long, whilst that to the west is short and steep.

On the eastern side, from what I have already stated, it will be seen that boulders often form a prominent feature in the landscape, but on the west they have hitherto been found to be wanting. Last year (1874), however, I found them at several places, especially in Louis Hills. They all seemed to point to the Laurentian backbone for their origin. Roches moutonnées are not so prominent upon the west as they are upon the east, but scratchings and groovings along the shore (which will be spoken of hereafter under the head of Coast-Ice) are common everywhere.[1]

Drift.—In addition to all these evidences of ice-work seen in the shape of boulders and scratched rock surfaces, we have here and there patched over the country large deposits of drift filled with regularly striated rock-fragments.

In the neighbourhood of St. John's the drift-covering is noticeably full of such stones. Similar material covering the country may also be seen in many other parts of the Avalon peninsula, where we have good sections of an unstratified clayey base, containing both pebbles and boulders.

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[1] Many of the effects of ice now seen in Nova Scotia are described by Dawson in his "Acadian Geology," p. 64, *et seq.*, as resembling those now produced by frost and floating ice. Blocks of stone are shown to have travelled from elevation to elevation, across valleys which may have been accomplished by ice-floes or bergs. Other blocks again are shown to have travelled from low plains to the summit of hills, which is explained on the supposition that the land at the time of their deposit being slowly subsiding, and the ice-fields of successive years raising them higher and higher.

Further to the north Mr. Murray has observed these superficial deposits occurring on a much larger scale. In Little Bay, near Terra Nova Mine, he has noted deposits consisting of "probably fifty or sixty feet of stratified clay, gravel, and sand containing modern marine shells at the height of about 40 feet above high-water mark."

In Hall's Bay, up Indian Brook, he also noted stratified deposits of clay, "which is sometimes of a reddish and sometimes of a drab or bluish colour." Although these stratified deposits appear to show a divergence from what has hitherto been observed by Packard and others in the neighbouring mainland of Labrador, they show considerable relation and similarity to observations which have been made further up the valley of the St. Lawrence in Canada. It would seem that at no very remote period Newfoundland has been almost if not entirely subjected to the action of ice. To this fact the rounded hills, the basin-shaped hollows, the scored rocks, the erratic blocks and the immense coverings of drift, all bear testimony; but the mode in which all these phenomena have been brought about is a matter so speculative that I shall refrain from doing more than indicating a possible manner in which they may have occurred, rather than attempting to give any definite solution to such an obscure enigma.

Conclusions. — The general conclusions which might appear naturally to result from a consideration of observations made by myself during two summers travelling in the island, and also those made by other geologists, are as follows :—

If Newfoundland has been steadily rising during past ages, as it now appears to have done at no very remote geological period, it may have been beneath the surface of the ocean. During the period when it was undergoing elevation, no doubt a considerable amount of debris and boulders were dropped by icebergs over its surface when the Laurentian backbone, which would be the first land to emerge, reached the surface, it formed a barrier for the coast-ice which would carry its load of boulders and strew them with those of the bergs. This latter, as will hereafter be shown, might to some degree have been influential in giving a definite character to the rising area. After the final emergence the climate of Newfoundland might still have been a cold one, and the same highlands which gave birth to coast-ice, probably next gave birth to glaciers which scooped and hollowed out a great portion of the remaining marine drift, and left the island with its present contour. After the raising of the great North-East and South-East ranges, first coast-ice flowed East and West, and afterwards the glaciers followed in a similar direction, and thus perhaps the origin of the boulders, those which are so curiously perched being due rather to the latter than to the former. Thus it would seem that icebergs and coast-ice preceded glaciers, but to say what might have come before the former of these agents, would only be diving deeper into the depths of a sea of speculation. From the scantiness and want of detail in their observations, it is useless attempting definitely to correlate them with those conditions observed in the adjoining continent of America, where it has been shown "that the oldest glacial deposits have yielded evidence of inter-glacial mild conditions" similar to those of the British Isles and Europe (Great Ice-age, Jas. Geikie, p. 428).

(*To be continued in our next Number.*)

III.—ON SCOTTISH MONOGRAPTIDÆ.

BY CHARLES LAPWORTH, F.G.S.

(*Continued from page* 321.)

(PLATES XII. AND XIII.)

§ IV.

Group 2.—Type, MONOGRAPTUS HISINGERI, Carr. sp.

Polypary broad, rigid; bearing overlapping, un-ornamented, linear or cup-like hydrothecæ.

14. MONOGRAPTUS HISINGERI, Carruthers. Plate XII. Figs. 1*a*-*f*.

Prionotus sagittarius, Hisinger; Léthea Suecica, pl. 38, fig. 6.
Monograpsus sagittarius, Geinitz; Die Graptolithen, Taf. ii. figs. 2, 3, 4, 6, 21. Richter, Zeitschrift d. Deutsch. Gesellsch. 1853, Taf. xii. fig. 19.
Graptolites Griestonensis, Nicol; Quart. Journ. Geol. Soc. vol. vi. p. 64.

Polypary four or five inches in length, straight or very slightly curved, attaining a maximum diameter of one-twelfth of an inch. Hydrothecæ short and broad cups, with subquadrangular section, 20 to 24 to the inch, without overlap, inclined at an angle of about 45°; outer edge convex distally, proximally impressed; apertural margin deep, concave, at right angles to the general direction of the theca; denticle triangular and inornate.

The sicula in this species is short and broad, and the proximal portion of polypary is consequently very abrupt. The polypary itself is usually quite straight throughout the whole of its extent, but sometimes there is a decided ventral curvature. The hydrothecæ afford the best characteristic of the species; they are short and broad cups, sacculate distally and proximally compressed, with a broad concave or straight apertural margin, which as a rule is placed perpendicular to the general direction of the theca. The sharply impressed proximal moiety of the outer edge forms a broad excavation, the deep apertural margin occupying nearly half the transverse diameter of the polypary. This hollow is so strongly marked, that in some views the ventral margin appears as if it were cut into a series of deep notches. An example of this nature seems to have been the original foundation for Nicol's description and figure of his *Graptolites Griestonensis* (*loc. cit. supra*). The denticle is sometimes ornamented with a very minute spine, which is slightly inclined.

This is the only Scottish form that can be referred to the *Prionotus sagittarius* of Hisinger (*Léthea Suecica*, pl. 38, fig. 7). It agrees with his species in the convexity of the outer edge of the theca, and in the concavity and obliquity of the apertural margin. (Comp. Plate XII. Fig. 1 *a*.)

Locality.—Rare in the Gala Group at Grieston, Broadmeadows, Glendearg, Packman's Barn, etc., and in the Riccarton Beds at Riccarton, Edgerston, etc.

Var. (*a*.) JACULUM, Lapw. Plate XII. Figs. 2 *a–d*.

Polypary similar in form to that of *M. Hisingeri*. Hydrothecæ overlapping each other for half their length, inclined at an angle of from 30° to 35°; narrow, with direct margins and expanded aperture, the edge of which is at right angles with the virgula, and originates a conspicuous acutangular denticle.

In the great majority of instances the polypary in this form appears to be quite straight throughout the whole of its length, which frequently exceeds ten inches. There is, in reality, however, a slight dorsal curvature, just sufficient to enable us to recognize the fact that the hydrothecæ are placed upon the concave margin.

The hydrothecæ are conical tubes, compressed below and having an expanded orifice, the edge of which, instead of being placed at right angles to the general direction of the theca, as in most *Monograpti*, is perpendicular to the virgula. The outer edge of the theca being straight, the denticle is necessarily acutangular in form, and is remarkably conspicuous. In specimens preserved in half-relief, the thecæ are seen to overlap one another for half their length—the point of origin of each lying precisely opposite the centre of the theca immediately preceding. In casts of the interior in iron pyrites, the groove in the cast formed by the separating walls is carried outwards to the virgula, and we have the fallacious appearance of even a far larger amount of overlap.

The most common appearance presented by this species is that given in Fig. 2*c*, the hydrothecæ being compressed in such a manner that the apertural margin of each stretches half-way across the body of the periderm.

Locality.—Confined to the highest zone of the Birkhill Shales at Dobbs Linn, Garple, Belcraig, etc.

With rare exceptions, all the members of the family of the *Dichograptidæ* possess hydrothecæ which appear after compression identical with those of *M. Hisingeri*. By a very natural error all fragmentary branches of species of that family have consequently been hitherto referred to this form under its commoner title of *Graptolites sagittarius*. Owing to the objectionable custom of determining species from fragments alone, the further mistake has been committed of confounding all the *Monograpti* of the present group under the same title. The perplexing confusion which has been the inevitable result of these erroneous determinations has effectually prevented the introduction of correct views regarding the vertical distribution of the various Graptolitic species.

15. **Monograptus cyphus**, sp. nov. Plate XII. Figs. 3 *a*—*d*.

Monograpsus nuntius, Geinitz; Die Graptolithen, Taf. ii. figs. 26, 27.

Graptolites sagittarius, Nicholson; Quart. Journ. Geol. Soc. vol. xxiv. plate xx. figs. 25, 26.

Polypary four to six inches in length; distal portion arcuate, and with an average diameter of one-tenth of an inch; rapidly narrowing in the proximal portion, which is either circinate or broadly recurved. Hydrothecæ 26 to 28 to the inch, arranged on the convex margin of the periderm at an angle of about 30°, long narrow tubes with direct margins, overlapping each other for about half their length; margin of aperture at right angles with the general direction of the polypary; distal thecæ inornate, proximal thecæ having their denticles prolonged into distinct spines.

This is the only fully known species in the present group in which the proximal extremity of the polypary is sharply recurved. In most specimens the broad curvature of the adult portion is continued to the sicula, but not unfrequently the proximal extremity is decidedly circinate. This peculiar curvature is one of the chief characteristics of the species.

In the distal portion of the polypary the hydrothecæ greatly resemble those in *Monogr. jaculum*, with which they further agree in the amount of overlap, and in their angle of inclination. They are, however, slightly more numerous proportionally. In the proximal division, on the other hand, there is a decided expansion immediately below the aperture, and the denticle is prolonged into a well-marked spine, which lies in the same plane with the broad apertural margin. Proximal fragments thus approximate in general appearance to some young examples of forms of the *Sedgwickii* type. These early spines are only seen on well-preserved examples; nor do they seem to have been invariably present, for compressed specimens are often met with in which the proximal portion was almost filiform, and the early hydrothecæ of the type of those of *M. intermedius*, Carr.

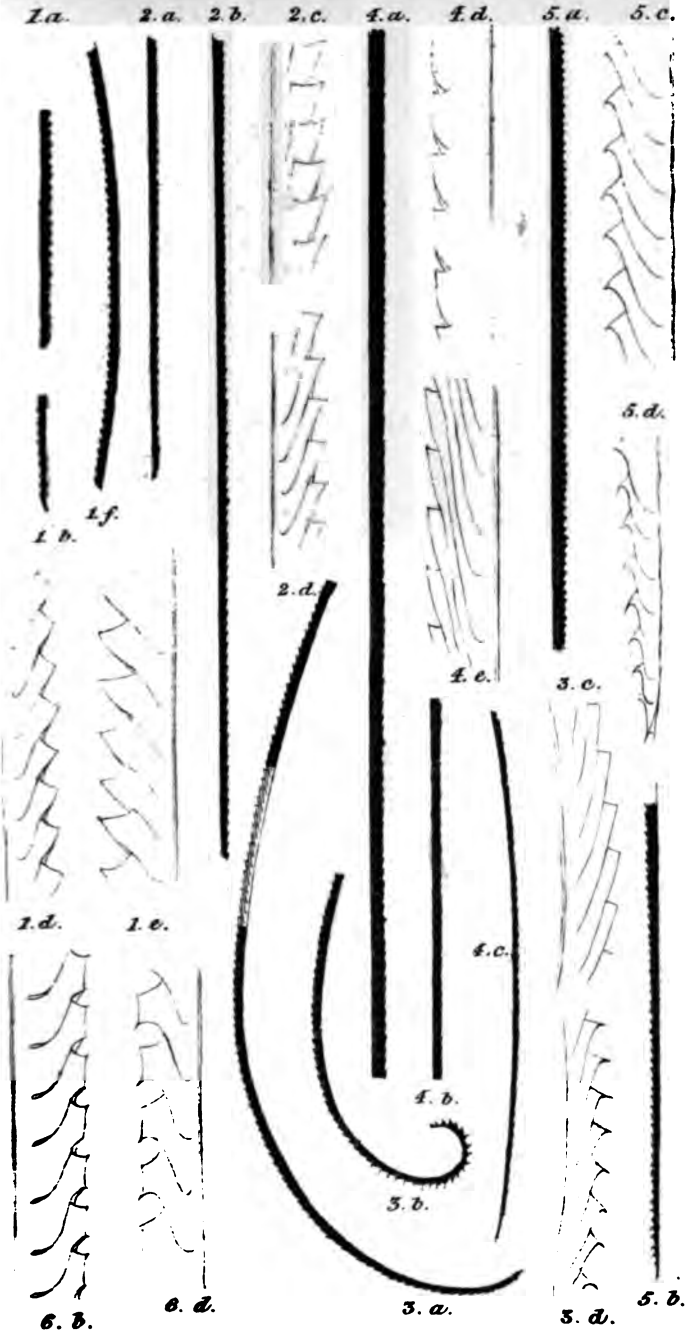
Monograptus nuntius, Barr., shows the dorsal curvature of this species, but judging from Barrande's figure and diagnosis, it appears to be quite distinct.

Locality.—Birkhill Shales, at Dobbs Linn, Frenchland, Garple, Belcraig.

16. **Monograptus leptotheca**, sp. nov. Plate XII. Figs. 4 *a*—*e*.

Polypary several inches long, straight distally, and with an average diameter of one-tenth of an inch; gradually narrowing in its proximal portion, which is of remarkable extent, and has a slight dorsal curvature. Hydrothecæ exceedingly slender, 18 to 20 to the inch, one-fifth of an inch in length, inclined at an angle of about 10°, and overlapping each other for three-fourths of their length; free portion of each slightly convex; apertural margin short, inclined, concave.

For the first few inches of length the polypary is as slender as those of the *Nilssoni* group, and there is an almost imperceptible



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Scottish Monograptidæ.

augmentation in diameter throughout the whole of its extent, which, judging from the fragments known, must have exceeded 18 inches. The curvature in the earlier moiety is very slight, but sufficient to enable us to perceive that the thecæ were arranged on the convex margin of the periderm.

The first-formed hydrothecæ, though almost identical in shape with those on the distal portion of the polypary, only overlap each other for about half their extent. As the length increases, this overlap rapidly augments, until, in the later and fully developed portion of the polypary, the hydrothecæ become remarkably slender flattened tubes, one-tenth of an inch in length, lying almost parallel with the line of the virgula. Only one-fourth of the length of each is free, the remainder being overlapped by the preceding theca. Each originates opposite the aperture of the third preceding it; so that a transverse section of the polypary crosses three hydrothecæ. The free portion is a little sacculate; the exterior margin lies parallel with the virgula; and the outer orifice is placed partly within the line of the ventral edge of the polypary. The interspace is very short and the apertural margin shallow, and either horizontal, or, in specimens in relief, a little acute. The denticle is generally somewhat mucronate, but is otherwise destitute of ornament.

From all other forms of the group, *M. leptotheca* is at once distinguished by the form and length of its distal hydrothecæ.

Locality.—Rare in the middle zones of the Birkhill Shales at Dobbs Linn and Frenchland Burn.

17. Monograptus vomerinus, Nich. Plate XII. Fig. 6 *a—e*.

Graptolithus colonus, Barrande; Grapt. de Bohème, pl. ii. fig. 4; Suess, Böhmische Graptolithen, Taf. viii. *a—f*.

Graptolites priodon, Nicholson; Quart. Journ. Geol. Soc. vol. xxiv. pl. xx. figs. 7, 8.

Graptolites vomerinus, Nicholson; Monogr. British Graptolitidæ, p. 53, fig. 21.

Polypary straight, rigid, four or five inches in length, and rapidly increasing in diameter to a maximum width of one-tenth of an inch. Hydrothecæ 20 to 22 to the inch, inclined at an angle of from 30° to 40°; short and broad cups, in contact for half their extent; distal portion of outer margin perpendicular, proximal portion sharply impressed—forming a deep excavation, and bearing a short horizontal mesial spine: apertural edge short, concave and normally devoid of ornament.

The polypary in this species is a straight, stiff rod, several inches in length, and with a test of remarkable thickness. The proximal end is abrupt, and the sicula short and broad. When preserved in relief, the hydrothecæ may be likened to those of *Monogr. priodon*, Bronn., truncated immediately at the point where they begin to isolate themselves. But the species to which it is most intimately allied, is *M. Hisingeri*, Carr. There is the same absence of overlap and the same short cup-like hydrothecæ. The latter, however, differ most materially in the details of their form. In the present species the distal moiety of each is perpendicular, while the proximal portion is inclined at an angle of about 30°—its free edge being impressed so as to form a deep excavation, into which opens the mouth of the hydrotheca immediately preceding. This excavation, the position and shape of the theca, and that of the thecal aperture, are all identical with those in the widely-removed genus *Climacograptus*. A further and most remarkable similarity is seen in the presence of a short stiff spine, which springs from the outer margin of the theca at the angle forming the distal termination of the excavation. This ornament (the mesial spine) is elsewhere strictly confined to the genus *Climacograptus*, Hall, and its most intimate allies; and is unknown among the *Monograpti* outside of the present species. In the adult portion of the polypary this spine is almost horizontal; but in the first half-dozen hydrothecæ, it is directed partly outwards, and partly towards the proximal extremity. The denticle, as a rule, is mucronate, and without ornament, but occasionally there is a rudimentary apertural spine, much inclined.

M. vomerinus is perhaps the best characterized species in this genus, differing from all others in the form and ornamentation of the hydrothecæ.

***Locality.*—Occurs in abundance in the Riccarton Beds at Elliottsfield, Shankend, Hindhope, etc.; and in the Lower Pentlands at Habbies Howe.**

§ V.

Group 3.—Type, MONOGRAPTUS HALLI, Barr. sp.

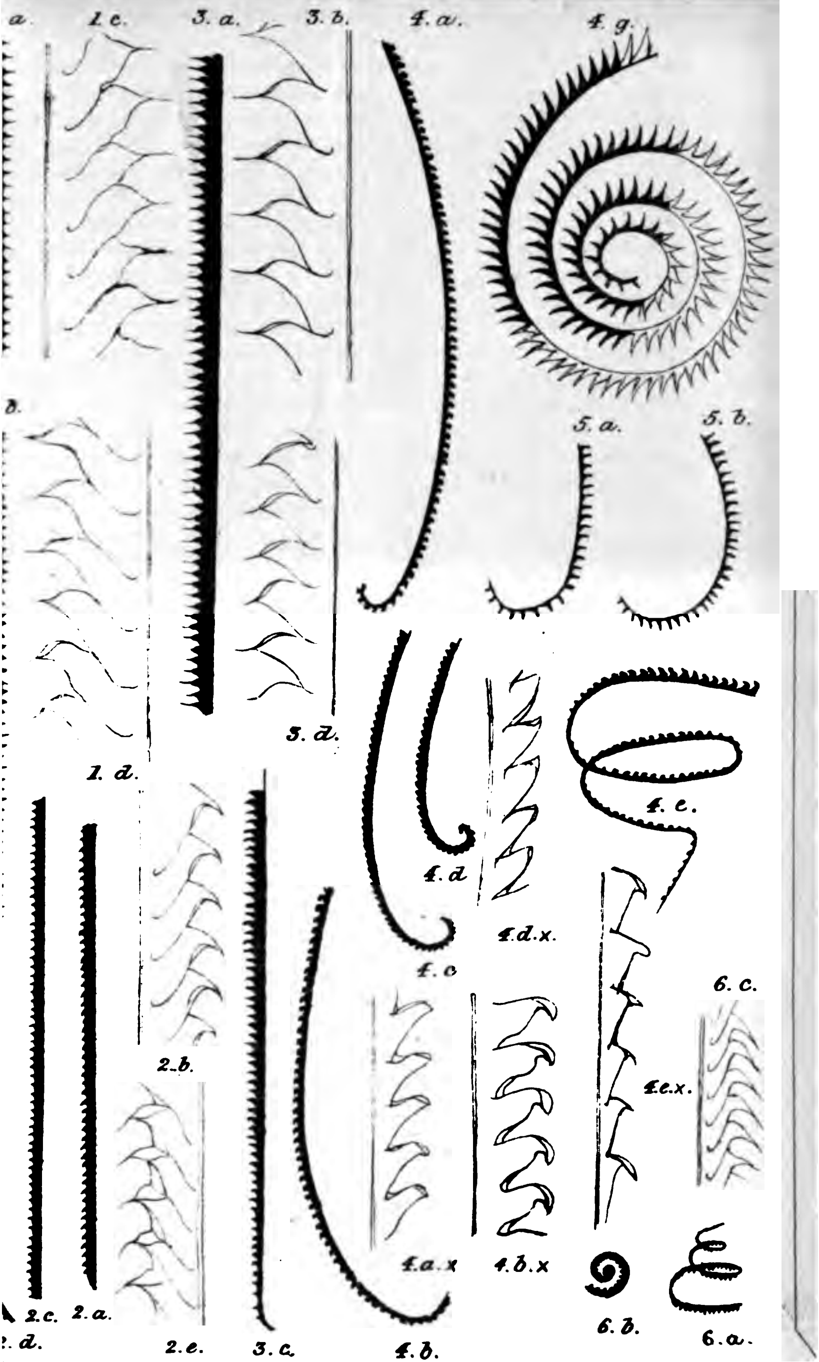
Polypary straight, stout, rigid; bearing wide overlapping tubular hydrothecæ with everted apertures, usually furnished with short apertural spines.

18. MONOGRAPTUS HALLI, Barr. Plate XIII. Figs. 1 *a*—*d*.

Graptolithus Halli, Barr.; Grapt. de Bohème, pl. 2, figs. 12, 13.
Monograpsus Sedgwickii, Geinitz; Die Graptolithen, Taf. iii. figs. 2, 3, 4.
Monograpsus Halli, Geinitz, ibid, figs. 5, 6, 7, 8.

Polypary several inches in length, straight or with a slight dorsal curvature, and having an average diameter of one-tenth of an inch. Hydrothecæ short and broad tubes, with a subquadrate section, 18 to 20 to the inch, inclined at an angle of from 50° to 60°, overlapping each other for about half their length, slightly contracting in the direction of the aperture, the margin of which is broadly convex, giving rise to a well-marked denticle, which is ornamented with a stout horizontal spine.

Commencing with a rapidly-expanding proximal portion, the polypary attains its normal diameter within the first three inches of its extent. Both straight and curved specimens are common; in the latter the hydrothecæ are arranged upon the concave margin. These afford the distinguishing characteristics of the species. In specimens preserved in relief, they are seen to be subconical in form, contracting slightly throughout, so that the distal portion of each



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Scottish Monograptidae

is isolated (Plate XIII. Fig. 1 *d*). This isolation is not apparent in flattened specimens, but the thecæ are pressed into complete contact with each other throughout. The margin of the thecal aperture is broadly convex, and there is usually a very distinct and somewhat mammilate denticle. In some specimens the latter is far more acute, and is prolonged to a distance equal to half the transverse diameter of the polypary. It is almost invariably furnished with a stiff horizontal spine, very conspicuous. The convexity of the apertural margin is not so apparent in examples which are in a state of half-relief, and it frequently happens that the broad aperture itself is directly visible, having been compressed from above.

The distant, broad hydrothecæ, with their peculiarly shaped apertural margin, and stout horizontal spine, at once separate this species from all its associates. Its nearest ally is *M. Riccartonensis*, Lapw.

Locality.—Monograptus Halli is confined to the highest zones of the Birkhill Shales at Garple, Frenchland, Mountbenger, Dobbs Linn, Craigmichan, Glenkiln, Duffkinnel, etc.

19. MONOGRAPTUS RICCARTONENSIS, sp. nov. Plate XIII. Figs. 2 *a*—*e*.

Polypary straight, or with a very slight dorsal curvature, and having a general diameter of one-twelfth of an inch. Hydrothecæ 26 to 28 to the inch, inclined at an angle of about 50° overlapping each other for a small fraction of their length; aperture wide, with a broadly convex margin; denticle long, everted and produced in a stout spine.

The proximal end of the polypary is usually bent sharply backwards, and exhibits a short and broad sicula. The hydrothecæ are very similar in form to those of *M. Halli*; and the thecal aperture shows the same sudden distal expansion and convex lateral margin. In almost every case the appearance presented by the compressed polypary is that given in Plate XIII. Fig. 2*e*, where it is compressed partly laterally, partly ventrally, and the whole extent of the thecal orifice, very slightly distorted, is presented to the observer. The lateral angle of the aperture clearly forms the denticle visible on the ventral margin, and gives origin to a stout spine, which is directed partly outwards, and partly towards the distal extremity of the polypary. As the same appearance is presented when the polypary is compressed, so that the polypiferous margin lies either to the right or to the left of the fossil, it is evident that the aperture must have been furnished with two spines, one on each of the lateral angles. This is probably the case also in the remaining spinose *Monograptidæ*, but the evidence is not usually so conclusive.

On a cursory examination, it appears clearly evident that it is the prolongation of that portion of the polypary beyond, or on the distal side of the aperture, that gives origin to the recurved ventral spine, and in poorly-preserved examples it is very difficult to resist the impression that it is given off from the base of the following hydrotheca.

M. Riccartonensis differs from *M. Halli* merely in the curvature of the polypary, and in the form and inclination of the apertural spine.

Locality.—Everywhere in the Riccarton beds; at Riccarton, Hindhope, Edgerston, Balmae, Dalton, etc.

20. MONOGRAPTUS GALAENSIS, sp. nov. Plate XII. Figs. 5 *a*—*d*.

Polypary five or six inches in length, straight or very slightly curved, and with a maximum diameter of one-twelfth of an inch. Hydrothecæ inclined at an angle of about 30°, 24 to the inch, overlapping each other for less than one-third of their length; slightly contracting in diameter towards the aperture, the margin of which is oblique, and forms a blunt triangular denticle.

The proximal portion of the polypary is comparatively long—the maximum diameter being rarely attained within the first three inches of its length. The extremity itself is blunt, and the sicula is similar in form to that of *M. priodon*, Bronn., but is of much smaller size. The hydrothecæ present appearances which differ according to their position and to the direction in which compression has been effected. In the adult portion of the polypary they are stout tubes, a little flattened transversely, and gradually contracting distally. The plane of the aperture is oblique with respect to the general line of the ventral margin, with which it makes an angle of about 120°. The denticle, though short and triangular, is very conspicuous. It sometimes bears a short spine, which lies in the same plane as the edge of the aperture. Near the proximal extremity the hydrothecæ are narrower, and there is a long acuminate denticle, generally strongly reverted. In some views the hydrothecæ appear to expand in the direction of the aperture, and the ventral margin is not unlike that in *M. Hisingeri*, Carr.

The polypary in this form seems to have been much thinner in texture than that of *M. priodon*, with which it is most frequently associated. It is always preserved as a mere carbonaceous film, often side by side with examples of the latter species in full relief.

In the profile view this species is at once distinguished from all other forms of the group, the ventral margin appearing as a direct line, along which project the minute triangular denticles at regular and distant intervals. It has been hitherto confounded with *M. colonus*, Barr.

Locality.—Gala Group in abundance, at Buckholm, Darnick, Glendearg, Wooplaw, Tushielaw, etc.

21. MONOGRAPTUS PRIODON, Bronn.

Lomatoceras priodon, Bronn.; Lethea Geogn., plate i. fig. 13.

Graptolithus vel *Graptolites priodon*, Barrande; Grapt. de Bohème, plate i. figs. 1—14. Geinitz, *Die Graptolithen*, plate iii. figs. 20 to 27, 29, 32, 34. Nicholson, Quart. Journal Geol. Soc. vol. xxiv. plate xx. figs. 6, 7.

This well-known species has often been correctly figured and described. It differs from all the remaining forms of this group in the shape of the distal portions of the hydrothecæ, which are so recurved that the apertures face the proximal extremity of the polypary. It is placed here on the ground of its close relationship to the typical form of *M. Halli.*

Barrande figures several Bohemian examples in which the polypary is more or less curved distally and has a circinate proximal portion. This variety seems to be absent from our Scottish deposits; all our examples are straight and rigid.

Locality.—Gala Group at Grieston, Tushielaw, Selkirk, Galashiels, etc. Girvan beds at Penwhapple. Riccarton Beds at Riccarton, Mosspaul, Elliotsfield. Lower Pentland Beds at N. Esk Reservoir, Habbies Howe, etc.

§ VI.

Group 4.—Type, MONOGRAPTUS SEDGWICKII, Portlock, sp.

Polypary straight, or spirally enrolled. Hydrothecæ rising from the convex edge of the periderm at a large angle; subtriangular in form, with curvilinear margins and subterminal aperture.

22. MONOGRAPTUS SEDGWICKII, Portlock, sp. Plate XIII. Figs. 3 *a*—*d*.

Graptolites Sedgwickii, Portlock; Rep. Londonderry and Tyrone, plate xix. figs. 1, 2, 3. Harkness, Geol. Journ. vol. vii. plate i. figs. 4 *a*, *b*, *c*. Nicholson, var. *spinigerus*, Quart. Journ. Geol. Soc. vol. xxiv. plate xix. figs 31, 32. *Monograpsus Sedgwickii*, Geinitz; Die Graptolithen, Taf. 3, fig. 1.

Monograpsus Heuberni, Geinitz; Die Graptolithen, Taf. 3, fig. 11.

Polypary several inches in length, rigid, straight or with a slight dorsal curvature, and having a maximum diameter of one-tenth of an inch. Hydrothecæ making an angle of about 60° with the line of the virgula, 16 to 20 to the inch, subtriangular in form, rapidly narrowing in the direction of the aperture, the margin of which is convex, oblique, prolonged, and ornamented by a strong rigid horizontal spine.

The proximal portion of the polypary is straight, perpendicular, and much wider than in any other form of the group. The sicula is about one-tenth of an inch in length, and together with its attached portion of the periderm is usually bent a little backwards. There is no variation in the general shape of the hydrothecæ throughout the whole of the extent of the polypary—those finally formed differing from those near the sicula in size alone. The base of each, or that portion which rests upon the common canal, is almost as broad as the length of the theca. There is no overlap, the hydrothecæ merely touching each other at their bases. The outer margin of each is concave and inclined at an angle which varies from 45° to 60°. The distal margin is almost horizontal and more or less arched—the outer portion forming the edge of the aperture. The denticle is strongly mucronate, and is prolonged in a stout spine about one-twentieth of an inch in length. In many examples this spine seems to be wholly wanting; but the known facts go to prove that it is universally present—its apparent absence depending either upon the angle of compression or the state of preservation of the fossil.

By some palæontologists this form is considered as identical with

Monograptus convolutus, His. As it differs from all the known varieties of that form in the size and straightness of the polypary and the spinose character of its hydrothecæ, we may more properly regard it with Carruthers[1] and Barrande[2] as a distinct and well-marked species.

Locality.—Highest zones of the Birkhill Shales at Dobbs Linn, Mountbenger, Garple, etc.

23. MONOGRAPTUS CONVOLUTUS, Hisinger, sp.

Prionotus convolutus, His.; Léthea Suecica, pl. xxxviii. fig. 7

Polypary from four to six inches in length, slender, arcuate, or coiled into a flat spiral; bearing closely-set hydrothecæ, in contact only, rising from the convex margin of the periderm at a large angle; subtriangular in form, and having subterminal, unornamented apertures.

Hisinger's original example of his *Prionotus convolutus* was possibly a spirally enrolled form of this Protean species. It is, however, very similar in appearance to the proximal portion of *Cyrtograptus Murchisoni*, Carr.; and it is impossible to identify it with any one of the following forms, which are our only known Scottish varieties.

Var. (*a.*) COMMUNIS. Plate XIII. Figs. 4 *a, b*.

Polypary almost straight distally; proximal extremity sharply incurved. Hydrothecæ 25 to 30 to the inch, short, triangular, pointed.

As a rule the polypary in this variety commences with a strongly recurved proximal portion, varying in length from one-half to a full inch in length. Here the hydrothecæ are linear and apparently isolated as in *M. triangulatus*. As the polypary grows, the thecæ become broader at their bases, till in the adult portion they are truly in contact. Sometimes the denticle is very acute, and is even a little recurved, reminding us of some examples of the *lobiferus* group.

Locality.—Common in the higher zones of the Birkhill Shales everywhere.

Var. (*b.*) FIMBRIATUS, Nicholson. Plate XIII. Figs. 4 *c, d*.

Graptolites fimbriatus, Nicholson; Quart. Journ. Geol. Soc. vol. xxiv. plate xx. figs. 3. 4, 5.

Polypary short, arcuate, with incurved proximal end. Hydrothecæ 30 to the inch, triangular, with rounded apices.

The hydrothecæ are shorter and broader than in var. *communis*, and they are much more closely arranged.

Locality.—A rare fossil; occurs only in association with the preceding variety.

Var. (*c.*) PROTEUS, Barrande. Plate XIII. Figs. 4 *e, f*.

Graptolithus proteus, Barrande; Grapt. de Bohème, plate iv. figs. 12, 14, 15. Suess, Böhmische Graptolithen, Taf. ix. figs. 2, 3. Geinitz, Die Graptolithen, Taf. iv. figs. 8, 14, 26, 27, 28, 29.

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[1] GEOL. MAG. Vol. V. p. 127.

[2] Defense de Colonies, part iv. p. 25.

Polypary bent into an irregular spiral, and with an extremely slender proximal portion bearing distant, adnate, linear hydrothecæ with everted denticles.

The distal hydrothecæ in this variety are longer than in var. *communis*, and much broader at their outer extremities than those in the following variety. Their apices are often a little recurved. The proximal portion of the polypary affords the chief characteristic of this variety. It is as slender as many of those of the *Nilssoni* group, and bears similar adnate hydrothecæ.

Locality.—In the highest beds of the Birkhill Shales at Duffkinnel, Mountbenger, etc., and in the Gala Group at Grieston, Broadmeadows.

Var. (*d.*) SPIRALIS, Geinitz. Plate XIII. Figs. 4 *g*, *h*.

Graptolithus spiralis, Geinitz; Neu. Jahrbuch für Mineral., 1842, pl. x. Barrande, Grapt. de Bohème, pl. iii. figs. 10, 11, 12. Nicholson, Quart. Journ. Geol. Soc. vol. xxiv. pl. xx. fig. 28.

Polypary long and slender, coiled up into a flat spiral, and bearing long linear acutely-pointed hydrothecæ.

The thecæ in this form are very similar in shape to those of the next species, to which it seems most intimately allied.

Locality.—Rare in the higher zones of Birkhill Shales at Duffkinnel, Sundhope, Dobbs Linn.

24. MONOGRAPTUS TRIANGULATUS, Harkness sp. Plate XIII. Fig. 5.

Rastrites triangulatus, Harkness; Quart. Journ. Geol. Soc. vol. vii. plate i. fig. 3 *d*.

Polypary rigid, slender, from one to two inches in length, arcuate distally, and with broadly incurved proximal portion. Hydrothecæ rising almost perpendicularly from the convex margin of the polypary, 25 to 28 to the inch, isolated, or in contact only; narrow, linear, with mucronate extremity and terminal aperture.

I have separated this form as a distinct species, because of the diminutive size and very characteristic shape of the polypary. It occurs in great multitudes in one zone of the Birkhill Shales, and always with the same general aspect.

The hydrothecæ are very similar to those of var. *spiralis*, Geinitz, but they are narrower at their bases and more deeply divided. Near the proximal extremity of the polypary they are distinctly isolated, and greatly resemble those of some forms of *Rastrites*. Distally their bases grow broader, and they appear to be truly in contact. This is not always the case, however, for in some specimens all the thecæ seem to be really isolated, as in *Rastrites*.

Locality.—Birkhill Shales, at Dobbs Linn, Garple, Glenkiln, Frenchland, etc. Gala Group at Sit Burn, Heriot Water, etc.

25. MONOGRAPTUS TURRICULATUS, Barrande. Plate XIII. Fig. 6.

Graptolithus turriculatus, Barrande; Grapt. de Bohème, plate iv. figs. 7—11. Nicholson, Quart. Journ. Geol. Soc. vol. xxiv. plate xx. figs. 29, 30.

Polypary slender, three to four inches in length, enrolled in a conical helix. Hydrothecæ 40 to the inch, subtriangular in form, with curvilinear margins; aperture terminal; denticle prolonged in a well-marked spine.

Our specimens of this species are all very small, the great majority of examples being less than one inch in length. They are usually compressed so as to present the appearance figured on Plate XIII. Fig. 6*b*.

This species is recognized at once by its small size, characteristic curvature and conspicuous apertural spines.

Locality.—It occurs rarely in the highest bed of the Birkhill Shales at Dobbs Linn, Whitehope, Frenchland, etc., and in the Gala Group at Meigle Hill, Buckholm, Elwand Burn, Cowdenknowes, etc.

EXPLANATION OF PLATE XII.

Figs.

1 *a—f* *Monograptus Hisingeri*, Carr., typical form. 1*a*—1*d*. distal portion; 1*b*. proximal end. Grieston Quarry. 1*c*. 1*d*. adult portion; oblique view. Elliotsfield. 1*e*. 1*f*. adult fragment. Long Sleddale, Westmorland.

2 *a—d* *Monograptus*, var. *jaculum*, Lapw. 2*a*. proximal; 2*b*. distal portion; 2*c*. characteristic view; 2*d*. in relief. Dobbs Linn.

3 *a—d* *Monograptus cyphus*, Lapw. 3*a*. adult; 3*b*. proximal portion; 3*c*. in relief; 3*d*. near proximal extremity. Dobbs Linn.

4 *a—e* *Monograptus leptotheca*, Lapw. 4*a*. adult portion; 4*b*. central; 4*c*. proximal; 4*d*. impression; 4*e*. cast. Dobbs Linn.

5 *a—d* *Monograptus Galaensis*, Lapw. 5*a—c*. distal; 5*b*. *d*. proximal extremity. Galashiels.

6 *a—d* *Monograptus vomerinus*, Nich. 6*a*. nat. size; 6*b*. compressed centrally; 6*c*. characteristic view; 6*d*. oblique view. Elliotsfield.

EXPLANATION OF PLATE XIII.

Figs.

1 *a—d* *Monograptus Halli*, Barrande. 1*a*. distal; 1*b*. proximal portion; 1*c*. flattened; 1*d*. in relief. Mountbenger Burn.

2 *a—e* *Monograptus Riccartonensis*, Lapw. 2*a*. *b*. distal portion in partial relief. Teiveshilly, County Down. (Coll. W. A. Swanston, Esq.) 2*c*. *d*. *e*. Elliotsfield.

3 *a—d* *Monograptus Sedgwickii*, Portlock. 3*a*. *b*. distal portion; 3. *c*. *d*. proximal end. Sundhope.

4 *a—h* *Monograptus convolutus*, His. 4*a*. *b*. var. *communis*, 4*c*. *d*. var. *fimbriatus*. Dobbs Linn. 4*e*. *f*. var. *proteus*. Coal-pit Bay. 4*g*. *h*. var. *spiralis*. (Coll. Prof. Nicholson.) Dobbs Linn.

5 *a—b* *Monograptus triangulatus*, Harkness. Dobbs Linn.

6 *a—b* *Monograptus turriculatus*, Barrande. Elwand Bank, Galashiels.

IV.—Pebble Ridges.

By T. Mellard Reade, C.E., F.G.S.

As a contribution to our knowledge of the formation of these very interesting "natural embankments of the sea," I may point to a little bay in Anglesea, immediately westward of the Bryn Ddu Limestone quarries on the north-east coast of Anglesea, about two miles and a half westward of Puffin Island. This little bay is not more than about a furlong across, and may be roughly described as semicircular in form, lying nearly due west to east from point to point. From being in miniature as it were, the ridge can be readily studied, and it is very striking to see how, commencing in the westward as a beach, it gradually rises into a ridge having very steep sides. No less remarkable is the way in which the stones increase in size as the ridge does in height. At the west end it may be described as composed of Limestone pebbles, with here and there a boulder, while at the east end it is built up almost entirely of large limestone boulders and blocks, many containing from one to two cubic feet and some more. Intermixed there are boulders from the size of the closed hand and upwards. The larger blocks are sub-angular and rounded, and no doubt get gradually worn down smaller and rounder, until they become "boulders," by being moved about by the sea; but some on the other hand, being thrown over on to the back of the bank, cannot be further affected by the waves. In this ridge, as I have pointed out is the case with the Chesil Bank,[1] the *stones follow the law of the bank itself, the largest being collected to form the highest part of the bank,* which in both occurs where the wave-action is most intense.

In the present instance there is no doubt about the direction of the gales being from the north-west, and here, as in the Chesil Bank, the large stones are collected at the lee end of the ridge. It is also a legitimate inference that they *travel* from the westward, as there are block-making rocks on that side of the Bay. If they did not travel, but simply moved up and down the slope of the beach, we should find the *smallest* where the wave-action was greatest, as they would be ground down *in situ.* This, in fact, is what takes place when they arrive at the end of their journey; but they are constantly being renewed by other "travellers," as the semi-rounded stones show. Nevertheless, it is remarkable to find the stones so assorted; for gravel and pebbles seem to have no place among the larger stones. These smaller objects most probably—like the mud derived from the attrition—get sucked out by the retiring waves, and travelling onwards are ground into powder, and finally end as mud deposits.

V.—REMARKS ON MR. BURNS'S PAPER ON THE MECHANICS OF GLACIERS.

By JAMES CROLL, LL.D., F.R.S.

I FEAR I must express my ideas very indistinctly, seeing that I am so frequently misunderstood by my critics. Quite recently a well-known American astronomer, in reviewing my book, "Climate and Time," devotes nearly a dozen pages to the refuting of views most of which I have never held. And in the July Number of the GEOLOGICAL MAGAZINE I am sorry to find a repetition of the same thing.

I feel certain, that had Mr. Burns been at the trouble to read my more recent and complete exposition of the Molecular Theory of Glacier Motion, given in Chapter XXXI. of "Climate and Time," he would not have published his criticism. The following extract from the chapter referred to will show how completely Mr. Burns has mistaken the theory:

> "This is the form in which my explanation was first stated about half a dozen

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[1] GEOL. MAG. Vol. I. Dec. II. pp. 286, 287.

years ago.[1] There is, however, another element which must be taken into account. It is one which will help to cast additional light on some obscure points connected with glacial phenomena.

"Ice is evidently not absolutely solid throughout. It is composed of crystalline particles, which, though in contact with one another, are, however, not packed together so as to occupy the least possible space, and, even though they were, the particles would not fit so closely together as to exclude interstices. The crystalline particles are, however, united to one another at special points determined by their polarity, and on this account they require more space; and this in all probability is the reason, as Professor Tyndall remarks, why ice, volume for volume, is less dense than water.

"'They (the molecules), like the magnets,' says Professor Tyndall, 'are acted upon by two distinct forces; for a time, while the liquid is being cooled, they approach each other, in obedience to their general attraction for each other. But at a certain point new forces, some attractive, some repulsive, *emanating from special points* of the molecules, come into play. The attracted points close up, the repelled points retreat. Thus the molecules turn and rearrange themselves, demanding as they do so more space, and overcoming all ordinary resistance by the energy of their demand. This, in general terms, is an explanation of the expansion of water in solidifying.'[2]

"It will be obvious, then, that when a crystalline molecule melts, it will not merely descend in the manner already described, but capillary attraction will cause it to flow into the interstices between the adjoining molecules. The moment that it parts with the heat received, it will of course resolidify, as has been shown, but it will not solidify so as to fit the cavity which it occupied when in the fluid state. For the liquid molecule in solidifying assumes the crystalline form, and of course there will be a definite proportion between the length, breadth, and thickness of the crystal; consequently it will always happen that the interstice in which it solidifies will be too narrow to contain it. The result will be that the fluid molecule in passing into the crystalline form will press the two adjoining molecules aside in order to make sufficient room for itself between them, and this it will do, no matter what amount of space it may possess in all other directions. The crystal will not form to suit the cavity, the cavity must be made to contain the crystal. And what holds true of one molecule, holds true of every molecule which melts and resolidifies. This process is therefore going on incessantly in every part of the glacier, and in proportion to the amount of heat which the glacier is receiving. This internal molecular pressure, resulting from the solidifying of the fluid molecules in the interstices of the ice, acts on the mass of the ice as an expansive force, tending to cause the glacier to widen out laterally in all directions.

"Conceive a mass of ice lying on a flat horizontal surface, and receiving heat on its upper surface, say from the sun; as the heat passes downwards through the mass, the molecules, acting as conductors, melt and resolidify. Each fluid molecule solidifies in an interstice, which has to be widened in order to contain it. The pressure thus exerted by the continual resolidifying of the molecules will cause the mass to widen out laterally, and of course as the mass widens out it will grow thinner and thinner if it does not receive fresh acquisition on its surface. In the case of a glacier lying in a valley, motion, however, will only take place in one direction. The sides of the valley prevent the glacier from widening; and as gravitation opposes the motion of the ice up, and favours its motion down the valley, the path of least resistance to molecular pressure will always be down the slope, and consequently in this direction molecular displacement will take place. Molecular pressure will therefore produce motion in the same direction as that of gravity. In other words, it will tend to cause the glacier to descend the valley.

"The lateral expansion of the ice from internal molecular pressure explains in a clear and satisfactory manner how rock-basins may be excavated by means of land-ice. It also removes the difficulties which have been felt in accounting for the ascent of ice up a steep slope. The main difficulty besetting the theory of the excavation of rock-basins by ice is to explain how the ice after entering the basin manages to get out again—how the ice at the bottom is made to ascend the sloping sides of the basin. Pressure acting from behind, it has been argued by some, if the basin be deep and its sides steep, will simply cause the ice lying above the level of the basin to move forward over the surface of the mass filling it. This conclusion is, owever, incorrect. The ice filling the basin and the glacier overlying it are united n one solid mass, so that the latter cannot move over the former without shearing; nd although the resistance to motion offered by the sloping sides of the basin may e much greater than the resistance to shear, still the ice will be slowly dragged out f the basin. However, in order to obviate this objection to which I refer, the dvocates of the glacial origin of lake-basins point out that the length of those asins in proportion to their depth is so great that the slope up which the ice has to ass is in reality but small. This no doubt is true of lake-basins in general, but it oes not hold universally true. But the theory does not demand that an ice-formed ake-basin cannot have steep sides. We have incontestable evidence that ice will pass up a steep slope; and, if ice can pass up a steep slope, it can excavate a basin with a steep slope. That ice will pass up a steep slope is proved by the fact that omparatively deep and narrow river-valleys are often found striated across, while hills which stood directly in the path of the ice of the glacial epoch are sometimes found striated *upwards* from their base to their summit. Some striking examples of striæ running up-hill are given by Professor Geikie in his 'Glacial Drift of Scotland.' I have myself seen a slope striated upwards so steep that one could not climb it.

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[1] Phil. Mag., March, 1869; September, 1870.

[2] "Forms of Water," p. 127.

"A very good example of a river-valley striated across came under my observation during the past summer. The Tay, between Cargill and Stanley (in the centre of the broad plain of Strathmore), has excavated, through the Old Red Sandstone, a channel between 200 and 300 feet in depth. The channel here runs at right angles to the path taken during the glacial epoch by the great mass of ice coming from the North-West Highlands. At a short distance below Cargill, the trap rising out of the bed of the river is beautifully ice-grooved and striated, at right angles to the stream. A trap-dyke, several miles in length, crosses the river about a mile above Stanley, forming a rapid, known as the Linn of Campsie. This dyke is *moutonnée* and striated from near the Linn up the sloping bank to the level of the surrounding country, showing that the ice must have ascended a gradient of one in seven to a height of 300 feet.

"From what has been already stated in reference to the resolidifying of the molecules in the insterstices of the ice, the application of the molecular theory to the explanation of the effects under consideration will no doubt be apparent. Take the case of the passage of the ice-sheet across a river-valley. As the upper surface of the ice-sheet is constantly receiving heat from the sun and the air in contact with it, there is consequently a transference of heat from above downwards to the bottom of the sheet. This transference of heat from molecule to molecule is accompanied by the melting and resolidifying of the successive molecules in the manner already detailed. As the fluid molecules tend to flow into adjoining interstices before solidifying and assuming the crystalline form, the interstices of the ice at the bottom of the valley are constantly being filled by fluid molecules from above. These molecules no sooner enter the interstices than they pass into the crystalline form, and become, of course, separated from their neighbours by fresh interstices, which new interstices become filled by fluid molecules, which, in turn, crystallize, forming fresh interstices, and so on. The ice at the bottom of the valley, so long as this process continues, is constantly receiving fresh additions from above. The ice must therefore expand laterally to make room for these additions, which it must do unless the resistance to lateral expansion be greater than the force exerted by the molecules in crystallizing. But a resistance sufficient to do this must be enormous. The ice at the bottom of the valley cannot expand laterally without passing up the sloping sides. In expanding it will take the path of least resistance, but the path of least resistance will always be on the side of the valley towards which the general mass of the ice above is flowing.

"It has been shown (Chapter XXVII.) that the ice passing over Strathmore must have been over 2000 feet in thickness. An ice-sheet 2000 feet in thickness exerts on its bed a pressure of upwards of 51 tons per square foot. When we reflect that ice under so enormous a pressure, with grinding materials lying underneath, was forced by irresistible molecular energy up an incline of one in seven, it is not at all surprising that the hard trap should be ground down and striated.

"We can also understand how the softer portions of the rocky surface over which the ice moved should have been excavated into hollow basins. We have also an explanation of the transport of boulders from a lower to a higher level, for if ice can move from a lower to a higher level, it of course can carry boulders along with it."—*Climate and Time*, pp. 523—527.

Mr. Burns wholly misapprehends me in supposing me to believe that the heat enters the glacier at its lower end and travels upwards. A glacier receives its heat from the sun on its upper surface, and that heat must of course pass downwards from the surface to the bed of the glacier. In representing the downward motion of the molecules, it is true, I began by considering the lower molecule and passed upwards, but I never meant to convey the idea that the heat took that path. Mr. Burns appears also to misapprehend me in regard to the origin of "Crevasses." I need not, however, enter into these points, as the criticism relates wholly to my first and imperfect representation of the theory, so that it is of no importance whether his conclusions be correct or incorrect.

NOTICES OF MEMOIRS.

Recherches sur les Fossiles Paléozoïques de la Nouvelle-Galles du Sud (Australie). Par L. G. de Koninck, A.M. Texte pp. 140, 8vo.; Atlas pls. 4, 4to. (Bruxelles, 1876.)

IN this memoir we have presented to us one of those careful and comprehensive works for which the pen of Prof. de Koninck has become celebrated. The structure of the Palæozoic rocks of New South Wales is familiar to us through the writings of the Rev. W. B. Clarke, the late Samuel Stutchbury, William Keene, and others; but with the fauna of these old rocks our knowledge was of a very limited nature. There are, it is true, the fine memoirs of Messrs. Morris, McCoy, and Dana; but they comprehend only the fossils of the Carboniferous formation of New South Wales, and do not to any extent touch upon those of the Lower Palæozoic rocks. Under these circumstances the appearance of the present memoir is particularly acceptable.

Prof. de Koninck's studies lead him to the conclusion that Prof. McCoy's view, expressed in 1861, as to the general specific identity of the marine fauna of the whole world in the earlier portion of the Palæozoic epoch, is also applicable to the Devonian and Carboniferous.

As it is to be remarked in connexion with a large number of Indian and Chinese Carbonifeous species, so with the Australian, they attain a size rarely equalled by their European or American representatives.

The memoir treats separately of the Devonian and Silurian forms respectively. Of the 59 Silurian species, 13 are considered by Prof. de Koninck to be new, and 8 doubtful. They are all of Upper Silurian type, and do not appear to differ in form and size from species of the same age in other quarters of the globe. The new species all belong to genera represented in Europe or America by closely allied forms. Two well-defined horizons are recogziable, a lower composed of argillaceous rocks, corresponding to the Upper Llandovery, and an upper of very hard quartzites, usually coloured red from the presence of oxide of iron, and white or grey crystalline limestone, corresponding to the Ludlow series. The species are nearly equally divided between the two groups, 32 occurring in the lower or Upper Llandovery, and 27 in the upper or Ludlow group. In the former the fauna is almost exclusively Molluscan and Crustacean, whilst in the latter Corals and Crustacea chiefly abound.

Passing to the Devonian, we find that 67 species are described, of which 30 are considered as new, and have their analogues in European or American Devonian rocks, except four, *Archæocyathus? Clarkei*, de Kon.; *Billingsia alveolarei*, de Kon.; *Niso? Darwinii*, de Kon.; and *Mitchellia striatula*, de Kon. The Upper Devonian series is indicated by the presence of such species as *Strophalosia productoides*, Murchison; *Chonetes coronata*, Conrad; *Rhynchonella pleurodon*, Phill.; *Spirifer disjunctus*, Sow.; and *Aviculopecten Clarkei*, de Kon. The chief remaining forms, especially those from the black limestone of Yars, indicate a somewhat lower horizon than the preceding five species, but at the same time more recent than the horizon represented by *Calceola sandalina*, Lamk. Prof. de Koninck states that *Archæocyathus? Clarkei* appears to take, in Australia, the place occupied by *Receptaculites Neptuni*, Defr., in certain European Devonian beds, especially those of Belgium. Under the name of *Mitchellia* is described a new and interesting genus of the family *Buccinidæ*, in which the mouth is elongated and much contracted. The occurrence of this genus in conjunction with a species of *Niso*, usually considered as a Tertiary genus, are the only anomalies to be noticed in the composition of the New South Wales Devonian fauna, as compared with that of Europe.

To the Rev. W. B. Clarke, M.A., F.R.S., through whose almost unaided exertions this collection was placed in Prof. de Koninck's hands, Palæontology owes a deep debt of gratitude. R. E., Jun.

REVIEWS.

I.—EXPLORATION OF THE COLORADO RIVER OF THE WEST AND ITS TRIBUTARIES. Report to the Secretary of the Smithsonian Institution. By J. W. POWELL. 4to. pp. 292, with 80 Illustrations, a Map, and Sections. (Washington, Government Printing Office, 1875.)

THIS is a large and handsome quarto volume, unexceptionable as to printing, and adorned with a quantity of really excellent views on wood, taken apparently from photographs, which for artistic effect and execution are of a very high order: indeed many of them seem stamped with the grandeur of the scenes they represent; and some, reminding one forcibly of the weird style of Gustave Doré, exhibit strongly the power with which really good illustrations can convey and enhance the appreciation of Nature's grandest physico-geologic features.[1]

The laborious operations of which Professor Powell's Report is the result were spread over the years 1869, 70, 71, and 72; so that the author writes with a detailed and extensive knowledge of this peculiar region, which claims attention—a region the very name of which prepares one for something of the marvellous. Hence we are not surprised to find, though the author has not all the descriptive power of a Burton, that his history bears much the character of the thrilling narrative of a desperate involuntary voyage through the cañons of the same river (which will be found in "*New Tracks in North America*"); accompanied too by the same accessories of danger, including loss of life; for three of the author's assistants, after electing to leave their companions, and strike across the country, rather than face further obstacles and risks of the cañon rapids ahead, are stated to have fallen into the hands of Indians, and been murdered by their arrows.

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[1] To point this remark, we might allude to the sadly different impression produced by comparing the wood-cut illustrations of Mr. Drew's new book on Kashmir, published by Stanford, London. Has the talent for illustration forsaken us for America? Surely not.

The whole length of the Colorado, with the Green River, of which it is the continuation, is about two thousand miles, while the country drained by the Colorado itself is some eight hundred miles in length, by three to five hundred in width, containing some three hundred thousand square miles. The lower third of this basin of the Colorado is but little above the sea-level, though mountains rise here and there from two to six thousand feet. And it is bounded on the north by bold, often vertical, cliffs. The upper two-thirds of the basin is from four to eight thousand feet above the sea, surrounded by ranges of snow-clad mountains, having altitudes of eight to fourteen thousand feet. "All winter long on its mountain-crested rim, snow falls filling the gorges, half burying the forests, and covering the crags and peaks with a mantle woven by the winds from the waves of the sea—a mantle of snow. When the summer sun comes, this snow melts and tumbles down the mountain-sides in millions of cascades. Ten million cascade brooks unite to form ten thousand torrent creeks; ten thousand torrent creeks unite to form a hundred rivers beset with cataracts; a hundred roaring rivers unite to form the Colorado, which rolls," through its cañons, "a mad, turbid stream, into the Gulf of California."

Where one of these streams traverses arid plains, it excavates its bed faster than the general level of the country is reduced by meteoric abrasion, and so "cuts deeper and still deeper till its banks are towering cliffs of solid rock," forming a gorge which is called a cañon. "For more than a thousand miles along its course the Colorado has cut for itself such a cañon, broken at some few points, where lateral streams join it. Every river entering the main one, every lateral creek, every brook, runs in a cañon; every rill born of a shower, and born again of a shower, and living only during these showers, has cut for itself a cañon; so that the whole upper basin of the Colorado is traversed by a labyrinth of these deep gorges." Some of these cañons are not more than twenty or thirty feet in width, and from six hundred to fifteen hundred feet deep. Others still comparatively narrow have a depth of more than an English mile. At one the author was baffled from day to day till the fourth had nearly passed before he could find a way down to the river. "Low *mesas* dry and treeless stretch back from the brink of a caon, often showing smooth surfaces of naked solid rock; in some places, where the rocks are richly-coloured and variegated marls, the surface is a bed of loose disintegrated material, through which one walks as in a bed of ashes; in some the disintegration of loose sandstone has left broad stretches of drifting sand, white, golden, and vermilion; in others conglomerates have left a paving of pebbles of many colours, polished by the drifting sands. All the scenic features of this cañon-land are on a giant scale, strange and weird. The streams run at depths almost inaccessible; lashing the rocks which beset their channels, rolling in rapids, and plunging in falls, and making a wild music which but adds to the gloom of the solitude."

After the cañons, the most remarkable features of the country are the cliffs, bold escarpments—often hundreds or thousands of feet in height, scores or hundreds of miles in length—from the vertical edges of which a gentle or imperceptible slope often leads to the foot of other cliffs. The region is still further diversified by short ranges of eruptive mountains, the materials of which issue through a vast system of fissures, whence floods of lava have poured, covering *mesas* and table-lands with sheets of black basalt. "The expiring energies of these volcanic agencies have piled up huge cinder-cones, that stand along the fissures, red, brown, and black, naked of vegetation, and conspicuous land-marks set in contrast to the bright variegated rocks of sedimentary origin."

Until the exploration guided by Professor Powell, this cañon-country was almost unknown. Stories were related, of people entering the gorges in boats, and being carried down with fearful velocity into whirlpools, to be "overwhelmed in the abyss of waters," or getting into "underground channels, and being never seen again" (for it was "believed the river was lost under rocks for several hundred miles"); again, of great water-falls, "whose roaring music could be heard on distant mountain summits;" or of "parties wandering on the brink of the cañon, vainly endeavouring to reach the waters below, and perishing with thirst in sight of the river which was roaring its mockery into dying ears." But nothing daunted, the author and his courageous assistants ran the whole river in boats, or let these over rapids by lines, making toilsome portages, calling the strange places they found themselves in sometimes, by such strange names as "Hell's half-mile," "Cañon of desolation," "Bonita bend," "Vasey's paradise," "Dirty-devil river," "Paru-nu-weap," or other equally euphonious Indian designations. At times they lost their boats and instruments, or had their provisions spoiled by immersion in the cataracts; sometimes they sat perched all night upon the rocks in drenching rain, and sometimes one of them or more was in such a predicament as this: "The boat is in very swift water, and Bradley is standing in the open compartment, holding out his oar to prevent her from striking against the foot of the cliff. Now she shoots out into the stream, and up as far as the line will permit, and then wheeling drives headlong against the rock; then out and back again, now straining on the line, now striking on the rock." A second line is brought, but he does not see it being passed to him; he takes his knife from its sheath, and steps forward to cut the line, evidently deciding that it is better to go over with the stream than wait for the boat to be dashed to pieces. As he leans over, she sheers into the stream, the stern-post breaks away, and she is loose. "With perfect composure Bradley seizes the great scull-oar, places it in the stern rowlock, and pulls with all his power (and he is an athlete), to turn the bow of the boat down stream. . . One, two strokes he makes, and a third just as she goes over. . . The boat is fairly turned, and she goes down almost beyond our sight, though we are more than a hundred feet above the river. Then she comes up again on a great wave, and down and up; then around, behind some great rocks, and is lost in the mad white foam below. We stand frozen with fear, for we see no boat. Bradley is gone, as it seems. But now, away below, we see something coming out of the waves; it is evidently a boat. A moment more, and we see Bradley standing on deck, swinging his hat to show that he is all right."

The rest of the party fare no better, their boat being swamped (as often happens) in the same rapid; but those who held together eventually accomplish their task. No wonder, when they emerge from the grand cañon of the Colorado, at the Grand Wash River "the quiet of the camp is sweet, as the river flows by in silent majesty, and their joy is almost ecstacy."

Of the whole book the first nine chapters are filled with descriptive details of the exploration, which—though varied by Indian legends, and remarks about the present and past inhabitants of the region, or the ruined buildings of the latter, the discovery of where a former expedition had been wrecked, and so forth—are, taken together, almost heavily monotonous, from the repetition of similarities in the story, the burden of which is cliffs, cañons, rapids, and "buttes," and the same thing over again. Chapter ten is a separate short report on a trip to the mouth of Dirty-devil river, by the geographer of the party, Professor A. H. Thompson, the two hundred and eighty miles traversed appearing to bear a striking resemblance to the rest of the region. The two following chapters are devoted to the physical features of the Valley of the Colorado, about which more anon. And the remaining sixty-four pages are occupied by zoological papers "On the Genera *Geomys* and *Thomomys*;" the Cranial and Dental Characters of *Geomydiæ*, by Dr. Elliott Coues; and Notes on the Salamander of Florida (*Geomys Gueza*), by Professor Brown Goode. None of which seem to have any particular connexion with the subject of the work as indicated by its name and title-page.

It is the chapters on the physical features of the country that will most interest geological readers, and of these we may add a few words.

The author starts with the assertion that these features are unique; and some are not reproduced, except to a very limited extent, on any other portion of the surface of the globe. Much of the region is in the arid country of the western portion of the United States, but not altogether waterless, judging from the local? rains described in his voyage down the river. Where the streams are permanent, flood-plains or river-flats are of course found; but the intermittent torrents run through deep, steeply sloping, often impassable channels, broken by falls; these narrow cañons being sometimes inclined from the vertical, or so crookedly cut, that one cannot perceive the sky looking upward from below.

The *mesas*, or rocky flats along the sides of the rivers, down in their gorges or cañons, seem to represent the flood-plains or river-flats of other rivers, and to result from causes limiting for a time the vertical erosion of the stream, which therefore acted laterally.

Every observer who has seen the effects of atmospheric erosion upon stratified rocks in regions of limited rainfall with long intermissions, and many of those who have studied this agency in climates where the rains are more constant, will recognize, both in the author's descriptions and in his illustrations, familiar features; and there is a certain amount of simplicity about the way in which he seeks to establish a somewhat mysterious classification of alcove lands, cliff features, and many forms of valleys, all of which must perforce have resulted from the long-continued atmospheric erosion, under certain climatal conditions, of a mass of gently undulating or rather more disturbed stratified rocks of different textures resting upon an older fundamental series—in short, though the examples are of high interest, there is nothing told of the configuration of the country that would not have been expected from the combination and reaction of atmospheric and geological structural conditions.

When this great river is found running at and across the Uintah mountain chain, up which it never could have climbed, yet dividing it to the very heart, the inference is plain that the river existed before the mountain chain did, and that the mountains are features of erosion as much as the river-valley itself. Our author goes further, however, and declares that the river did not cut its way down through the mountains from a height of many thousand feet, but that the mountains were lifted; while the river, remaining at much the same level, cleared away the obstruction by cutting a cañon. He likens the action to that of a log cut by a saw-mill, where fresh parts of the log are continually opposed to the saw—represented by the river. This action the author calls "corrosion," but while the elevation is stated for a fact, the reasons for his opinion that this exceptional cause was simultaneously in operation are not detailed; and, though he admits an enormous amount of the rocky surface of the country to have been denuded, he would suggestively involve possible changes in the level of the sea by contraction of the earth or other cosmic changes, rather than allow that these great cañons could have been excavated simply by the discharge of the surface waters. Faults he has found coinciding with lines of cliffs, but he traces no direct connexion between them and the cañon features.

An attempt is made to classify all the valleys by their relation to the curvature or position of the strata which they traverse, which at the outset must be weak, because these relations may be quite accidental, and it is not necessary that, in order for valleys to exist, the rocks should be stratified at all. A *diaclinal* valley is thus described as one cutting across an anticlinal fold; but as this is found to include two of the other systems of the author—namely, *cataclinal*, in the direction of the dip—and *anaclinal*, running against the dip of beds—the subject is hardly worth following further than to say that possibly some such names as a "*synclinal valley*," i.e. one running on the axis of a synclinal fold or its converse, might be found useful as short descriptive terms, if dissociated from the idea that their existence was due to any law connected with the folding of beds, rather than to accidental circumstances.

As far as the geology of the region can be gathered from these pages, it appears that the country has a basement of granitic or metamorphic rocks called granite by the author, though he tells us they are not granite, but crystalline schists, with dykes and beds of greenstone and granite; these are succeeded by unconformable beds of vitreous sandstone 10,000 feet in thickness, again unconformably overlain by several thousands of feet of the Carboniferous, Triassic, (possibly), Jurassic, Cretaceous, and Tertiary formations.

The volume is accompanied by a sketch-map of a part of the country explored, and a profile showing the relative difference in the form and elevation of the ground adjoining the Colorado and Mississippi rivers. It is to be welcomed as an important contribution to our knowledge of a highly interesting *terra incognita*, and perhaps as an earnest of further geological details, for which the author appears to have collected materials, which, read by the light of modern and moderate information, may prove a valuable addition to recent research.

II.—CRITICAL OBSERVATIONS ON THEORIES OF THE EARTH'S PHYSICAL EVOLUTION (concluded). By Capt. C. E. DUTTON, U.S.A. (The Penn Monthly. Philadelphia, June, 1876.)

Second Notice.

THE first part of these "Observations," which appeared in the May number of the *Penn Monthly*, was noticed in our last issue. The concluding portion has since been published, and our readers will no doubt be interested to learn what Captain Dutton has to offer in place of the "contractional hypothesis," against which he has advanced so many weighty objections—remarking by the way that these objections lie not so much against every form of the "constructional hypothesis," as against those which attribute the diminution of the earth's volume to mere cooling; and especially to that which assumes the cooling to have affected a *solid* earth, devoid of any liquid substratum beneath the superficial crust. They will, upon perusal of what follows, probably agree with us, that, although in his former article he declines claiming for his forthcoming views the dignity of a theory, they nevertheless deserve that appellation.

Rejecting the contractional hypothesis, and assuming that the cooling of the earth is still in its earlier stages, it will follow that alternations of emergence and submergence, and those elevations and depressions which occasion the irregular profiles of the earth's surface, have not been relative movements due to a variable amount of convergence towards the earth's centre, but have been *absolute*—now upwards and now downwards. Plateaux and continents are true uplifts, and ocean bottoms are true subsidences. Now if we regard any uplifted area at the surface as being the base of a cone having its vertex at the earth's centre, such an uplift [if absolute and not relative] would involve an increase in the volume of the cone. But volume is the quotient of mass by density. Therefore an increase of volume must be attended, either by an increase in the quantity of matter, or by a decrease of the density of the cone, or by both together. The problem thus becomes narrowed to the inquiry whether by any processes a rising area can receive an accession of mass, and a sinking area lose mass; or else respectively lose and increase in density.

Although deposition and denudation may add or subtract matter from an area, these changes will not account for the facts to be explained. The addition or subtraction of matter must be in the subterranean regions if it exist at all. We may here have recourse to the suggestion of Babbage and Sir J. Herschel, that the sea-bottom, becoming overloaded by material denuded off the neighbouring land, the plastic matter supposed to exist beneath is protruded in the direction of least resistance, that is towards the unloaded land.

Thus a static equilibrium is maintained, and the problem becomes a hydrostatic one. For it is quite clear, that if the crust of the earth rests everywhere upon a liquid, or even considerably plastic support, the altitude of every portion of it is determined solely by the laws of hydrostatic equilibrium. But the utmost that the movements arising from this cause, as at present alleged, could effect would be the maintaining of the respective areas at their old levels, in spite of denudation on the one hand and the deposition and building up of strata on the other. It does suggest a mode by which a land area may receive beneath it an accession of mass, but only to a very limited extent; and how an oceanic area may lose mass, but only to an amount equivalent to the gain in stratification.

There is another way in which the required additions of mass may be conceived to occur, and that is by the permeation of water.

There is a general tacit assumption, that in the progress of the evolution water gradually penetrates into the profounder depths of the earth, and into the presence of the primal heat. In this manner have been explained the large quantities of water brought up by lava, and incorporated with it, and the veins filled by minerals precipitated from watery solution. This penetration is commonly believed to be effected, not solely by the way of fissures and cracks, but to include the complete permeation of the rocks by water: else how could lavas be supersaturated with it, metamorphism effected by it, and mineral veins filled by segregation from the rock walls or from below? But it is usually supposed with apparent justice, that the penetration is limited as to depth by the repulsive power of heat, which increases at a rate sufficiently rapid to overcome at a greater or less depth the effect of pressure to keep it [the water] in a liquid state. Yet this limit is presumably receding with the secular cooling of the earth into lower depths. Whether the inverse process—the elimination of water from the lower depths to which they may have penetrated—is possible, thereby constituting a diminution of mass, is a question which will be alluded to further on.[1]

Having thus alluded to causes leading to change of *mass*, the author proceeds to discuss those which may affect the *density*, and it is here that the novelty of his suggestions appears.

Change of density due to secular cooling alone has been shown to be unimportant. Yet there is another possible cause which seems to have been quite overlooked, and if it should prove to be a *vera causa*, its importance will be immense. It has lately been established that water, under requisite conditions of heat and temperature, has a powerful chemical reaction upon the materials of which the ordinary rocks are composed. M. Daubrée enclosed various minerals in thick-walled tubes of iron containing water, and sealed hermetically by welding. The tubes were then exposed to temperatures of 600° F. and more, for a number of days, and after cooling were opened and examined. It was found that the water had acted very energetically upon the enclosed substances, breaking up their original combinations, and that new crystalline substances had been formed. Thus common glass and clay, which contain the chief elements which make up the rocks of the earth, were converted into felspar, mica, quartz, and hornblende, which are the chief minerals of the crystalline rocks. These experiments were quickly followed by others of a similar character, all leading to the same conclusion—that water reacts energetically, even at moderately elevated temperatures, upon minerals which are not sensibly attacked by it at lower ones; and that siliceous compounds in a vitreous condition, like glass, obsidian, and many lavas, as well as many materials which are found in sedimentary rocks, are broken up and reconstructed into new crystalline forms. Metamorphism then does not require a temperature sufficient to produce dry fusion. The required changes may take place at a heat below redness, though it can hardly be doubted that the reaction of water, and its solvent power, increase with the heat, so long as the pressure is sufficient to keep it in its liquid form. In the course of these experiments it was observed that the minerals in their transformation exhibited changes of density, which were sometimes surprising. It is considered probable that minerals in this state of "hydrothermal solution" are swollen and bulky, taking a form similar to that presented by silica in the gelatinous condition, and alumina in the hydrated state. These hydrated minerals are of a considerably lower specific gravity than their corresponding crystals, and in general all earthy materials are less dense in the amorphous (uncrystalline) than in the crystalline state. The admixture of water would obviously render the former still less dense, and such is known to be the case.

[1] We do not however perceive that this question, to which we are disposed to attribute great importance, believing with the late Mr. Scrope that the water *eliminated* by volcanos is an original constituent of the nucleus, has been adequately, *if at all*, *discussed* by Captain Dutton.

In this hydrothermal action then, Captain Dutton finds a probable cause for changes in the density of the nether rocks. A decrease of density, accompanied with an expansion of volume, should occur when water finds access to them at high temperatures; an increase of density with diminished volume should take place, when from any cause new and stable crystalline compounds are formed. In truth any chemical change below the surface of the earth should be accompanied, as all reactions are, by changes of volume in the reagents. Between the amorphous and crystalline states of common minerals, the change would average one-tenth, or one-eighth, and would be materially increased by the addition or loss of water—a change far exceeding that which would result from any probable change of temperature.

Masses of crystalline rocks, which have been subjected to hydrothermal action, show, by the convolution of their layers, that they have been evidently rendered plastic by such action; while lavas are quite liquid. Daubrée believed that this plastic condition might exist at as low a temperature as 600° F. The same conclusion may be reached by the consideration, that sedimentary rocks, while undergoing metamorphism, have been evidently rendered plastic, and it is impossible that they can have been buried deep enough to have been so rendered by heat in the dry way.

The author's theory consequently rests upon the basis of the following propositions. 1. The hydrothermal theory of metamorphism is taken for granted. 2. That process consists in an intensified solvent power of water over rock materials under great pressure, and at a temperature approaching to redness. 3. This state of silica, alumina, etc., is presumed to be essentially the same as when those oxides are obtained in the laboratory in the soluble hydrous condition, in which their specific gravity is considerably less than in the crystalline anhydrous form. 4. Hence it is inferred, that the condition of hydrothermal solution is attended with a large diminution of specific gravity. 5. Inversely, a fall of temperature, or decrease of pressure, is followed by the crystallization of the materials, and an increase of density.

If the deeply buried rocks are composed, like those at the surface, of silica, alumina, and the alkaline and earthy bases, it would require but a very moderate degree of expansion to render their specific gravity less than that of the rocks above them. If, when in this expanded condition, they become also plastic, then the strata resting on them will be in unstable equilibrium.

So long as the foundations of the [upper] strata are rigid, or denser than them, expansion would be attended by no further disturbance than a vertical upward movement, and such minor complications as might arise from inequality of the process, or of distribution of the load. But as soon as the density of the underlying layer becomes less, a new order of movements must ensue. It has already been remarked that the coherence of a mass of strata of great extent is practically nothing. In masses of less extent, as in a single mountain ridge, it would be appreciable. Hence under the conditions of unstable equilibrium assumed, a large extent of crust would divide and subdivide itself, until the fragments were small enough to give an appreciable value to their coherence. The directions of the lines of fracture would be determined by the inequalities of the distribution of deposit. The problem thus becomes a hydrostatic one. The axes of maximum deposit become the axes of future synclinals, and the axes of minimum deposit mark the positions of future anticlinals. The heaviest portions sink into the lighter colloid mass beneath, protruding it laterally under the lighter portions, where by its lighter density it tends to accumulate. These movements are the plainest sequences of well-known hydrostatic laws, which we cannot hesitate to accept if we accept the premisses. The resulting movements would be determined, first by the amount of difference in the densities of the upper and lower masses, and secondly by inequalities in the thickness of the strata. The forces now become adequate to the building of mountains, and the plications of strata; and their modes of operation agree with the classes of facts already set forth as the concomitants of those features. Such is Captain Dutton's theory, which he next proceeds to apply to plications—to "mountain building"—and to volcanos.

When once indicated, the consequences of this theory can be followed out by the geological thinker; but at the risk of tediousness it seems but right to relate the author's own application of it in the more important cases.

Wherever loads of sediment become heaviest, there they sink deepest, protruding the colloid magma beneath them to the adjoining areas which are less heavily weighted, forming at once both synclinals and anticlinals. The disturbance would be in proportion to the difference of densities of the upper and lower portions, and to the plasticity of the latter. Hence would arise (1) low undulations, which occur where the bedding is less unequal; (2) larger features, as in the Jura and Appalachians, where heavy beds of deposit have accumulated rapidly in long and narrow belts. These have subsided, forming troughs, in which the sediments have continued to gather, and augment the disturbing cause. The material displaced by the sinking masses must have been driven beneath the anticlinals, turning up their edges with increasing inclination, and pushing up higher the strata above them In this position the two branches of the inclined strata form great top-heavy masses, with a powerful tendency to greater inclination; and the great blocks may even become inverted. By the theory he also seeks to explain the fact, that the steeper inclination of the dips in the coast-range of California, and in the Appalachians, is from the area of chief deposit towards what was the lightened land, from whose denudation the materials were derived. (3) We have mountain building. All typical mountains, consisting of granitoid cores protruded through strata, and towering above them, stand upon lofty tables. Such mountains are quite unknown in low countries, being a series of sharp pinnacles and ridges planted upon a broad expanse of high lands. The uplifting of the regional belts [of high land] on which they occur, by columnar expansion of the underlying magma, involves at once the conclusion, that the magma must ultimately reach a degree of density much less than that of the overlying rocks, which break up into prisms or folds, and sink or recoil away from the axis of the rising colloid mass. The objection might be raised, that the materials of mountain cores are now as dense as those of the adjoining strata, and where they are cold and crystalline, they are so. But according to this argument, the case is quite different at an inconsiderable depth. Beneath the mountain crests, the colloid mass preserves its greater volume near to the surface; beneath the adjoining strata it has been protruded laterally away and extravasated; the quantities of matter in the two columns being equal. Of this an indication is found in the very rapid rate of increase of temperature with depth which is found in mines sunk in the granitoid cores and flank,s of such mountains.

Volcanos are the extreme cases of an extreme class. The alligation of a large quantity of water in the lava renders it of comparatively small specific gravity, and it needs for the expelling force, even from a lofty summit, only the weight of the strata which cover the liquid reservoir. Volcanos occur where hydrothermal lavas exist, and are displaced by the subsidence of sediments. Hence their situation in mid ocean, or on its shores, or even upon the shores of inland lakes, where deposits are going on abundantly. And the author illustrates this view by several American examples. Perhaps as good a sample as any is the Uintah range. Disregarding the enormous Cretaceous deposits, the fresh-water Tertiaries turned up on the flanks of these mountains are 10,000 feet thick. That these beds subsided by their gross weight as rapidly as they grew, admits of no shadow of doubt. The mountain cores against which they recline are rocks, which give every indication of having been extravasated upwards. What became of the matter displaced by the sinking strata, and whence came the displaced matter which slopes down to their upturned edges, and how can the conclusion be avoided that they are one and the same? If it be objected that the greater altitude of the mountains should overbalance the weight of the lower strata, the reply is: The mountains are there, and at their feet are the sunken strata. Grant that the density of the mountains is less, and the argument becomes a demonstration. Conformably to this view, the position of volcanos around the outskirts of maximum sediments, which are usually shore deposits, becomes a normal one. The liquidity of lavas renders their extravasation easy at the points of greatest relief, where rents are most liable to occur; and their lower density is a sufficient reason for the altitude at which they are poured out.

Captain Dutton does not claim for the above argument that it is a solution of the general problem of the evolution of the earth's physical features, but intends it as an attempt to indicate a highly important consideration hitherto neglected. And he considers that it rests upon facts of geological structure, that are held to admit of no other possible interpretation.

Geologists will probably look to the author to show that, as he has proved the inadequacy of the contractional theory, as usually understood, so he will establish by some calculation, based on probable values of the thickness of rocks affected, and of the changes of density due to hydrothermal action, that the inequalities of the earth's surface are not of greater magnitude than his theory would account for.

CORRESPONDENCE.

THE SILURIAN ROCKS OF THE LAKE DISTRICT.

SIR,—My time at present is too much occupied with my official duties to answer Mr. Hicks's letter in the last GEOLOGICAL MAG. at any length. Besides, the results of my survey of the Silurian Rocks of the Lake District must be recorded on the maps and in the memoirs of the Government Geological Survey. But I should like to know from Mr. Hicks if it is from the fossil evidence or from a careful stratigraphical survey of the rocks of the Lake District that he speaks so confidently of their position. If from the former, there is the danger of arguing in a circle. Certain beds were supposed to be Lower Silurian, therefore the fossils collected from these beds were considered Lower Silurian fossils; and so now these beds are called Lower Silurian, because they contain Lower Silurian fossils. But if a careful stratigraphical survey went to show that these beds were connected with the Upper and not the Lower Silurian, the fossils in these beds would no longer be characteristic of Lower Silurian.

I feel confident that the Stockdale shales of the Lake District are the equivalents of the Tarannon shales of Wales, and the Coniston grits and flags equivalent to the Denbighshire grits and flags, and that the Tarannon shales of Wales overlie the Llandovery rocks.

H.M. GEOL. SURVEY, KENDAL, W. TALBOT AVELINE.
July 8, 1876.

THE EROSION OF LAKE-BASINS BY GLACIERS.

SIR,—Some of Mr. Fisher's interesting remarks on the excavatory action of glaciers seem to call for a few words of reply. It is quite true that the "possibility of the erosion of a great lake by a glacier has not been disproved," and that observations made on the Swiss glaciers now cannot do it; but these observations (and that is all I have ever contended) may render the theory probable or improbable. I doubt whether, in the sense in which we both should use the word, *proof* would ever in any case be possible. Mr. Fisher, however, seems not to have apprehended the point on which I have always laid most stress in my reasoning (which did not fall within the scope of my last communication to you), viz. that the great majority of Alpine valleys show no tendency to lake-basins, in places near, but above, the present lakes; where the conditions of glacial action must have been as nearly as possible the same as over the area of the basin, that is to say, that if you ascend a valley from the head of a lake, you often find it throughout a true valley of river erosion, only very superficially modified by glacial action. Surely the glacier would have "tried its 'prentice hand" now and then before, for example, excavating Como.

I demur to Mr. Fisher's statement that if a glacier would be competent to deepen a lake basin, it could no doubt originate it. This may be only to say, "if a thing can be done under very favourable conditions, it can be done under all conditions," which, as it seems to me, is not a safe conclusion. Besides, if a basin exists into which the glacier descends, *What made the basin?* I may grant that a whetstone sharpens a razor, but doubt whether it is usually the tool with which razors are made.

With regard to the latter part of Mr. Fisher's letter, the hypotheses which he advances are such as it is almost impossible to disprove; for it is very difficult to understand what would be the procedure of the subglacial water in a lake-basin. I do not, however, think that under the circumstances there would be much abrading action exercised by the water (below the level of the rim of the basin) which is passing between the rock and the ice. A subglacial stream usually either drills out a tunnel through the ice or furrows a channel in the rock below, so that its erosive action is limited to a small area; what it would do in the case of a lake-basin I can hardly say. Possibly it might continue to act in the same way, but if it did not, and a layer of water were introduced between the rock and the ice, throughout the basin, I imagine there would be little motion in this, and it would rather be unfavourable to denudation and favourable to accumulation of sediment.

With regard to Mr. Hugh Miller's letter, I may remark that he misses the point that I, and I think that I may venture to say my friend Mr. Judd, have always maintained—viz. that because glacial erosion may seem the simplest explanation of certain *tarns*, therefore it is to be applied to certain *lakes*. Further I may remark that the infrequency of *sharp* synclinals does not militate against the subsidence theory of lakes. Those who uphold this theory do not require sharp synclinals, as Mr. Miller will find if he will draw the lakes on a true scale. He has forgotten an argument often used by his friends.

T. G. Bonney.

St. John's College, Cambridge, *June* 12, 1876.

TRUE AND APPARENT DIP.

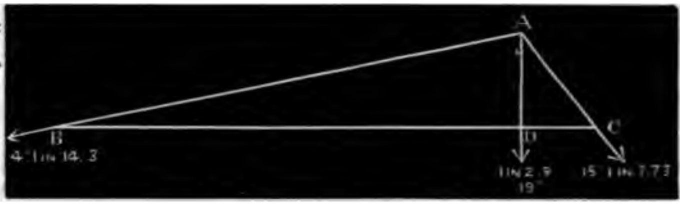
Sir,—Mr. Hill is a decided improvement on Mr. Penning, and I think I can improve a little on Mr. Hill. There are many excellent geologists to whom Trigonometry is a sealed book, and who not unnaturally look upon sines and cosines, tangents and cotangents, with a mixture of suspicion and dislike. But all geologists know what is meant when the dip of a bed is said to be 1 in 6; and it will remove the alarm which trigonometrical symbols are apt to raise in the minds of non-trigonometrical geologists, to be told, that, if a bed dips 1 in 6, the cotangent of the angle of dip is 6.

Bearing this in mind, Mr. Hill's construction may be thus simply expressed:—

Let the dips observed along two lines AB, AC, Fig. 1, be 1 in m and 1 in n; make AB m units, AC n units in length; join BC, and draw AD perpendicular to BC.

Then AD is the direction of the full dip, and if AD contain d units of length, the full dip is 1 in d.

Fig. 1.



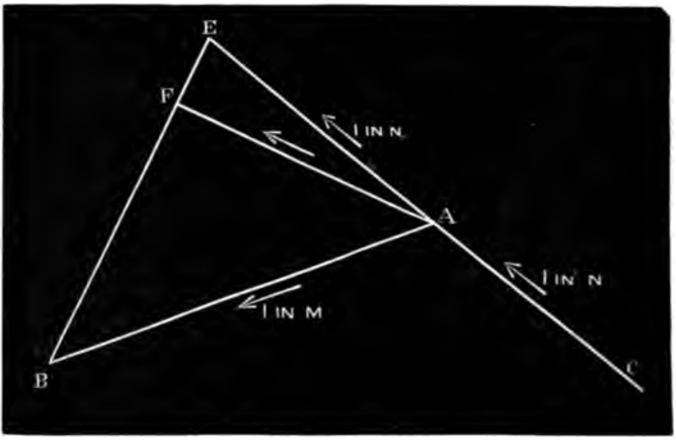
A similar construction will give the apparent dip in any direction when the full dip is known. Let AD be the direction and 1 in d the amount of the full dip; AB the direction in which the dip is required.

Make AD d units in length, draw DB perpendicular to AD meeting AB in B.

Then if AB contain x units of length, the dip along AB is 1 in x.

If the two dips, instead of being both towards or both away from A, be one towards and one away from A, produce one of the lines AB or AC to E, Fig. 2, make AB, AE, m and n units in length, draw AF perpendicular to BE, and AF will give the direction and amount of the full dip as in the first case.

Fig. 2.



For small angles the value of the dip expressed as one in so many which corresponds to a given number of degrees, may be obtained approximately by finding how often the number of degrees is contained in 60. In the table below the first column gives the value correct to two places of decimals for the angle opposite; in the second column are the values given by the above approximate rule; in the third the angle to the nearest minute that corresponds to the values in the second; and in the fourth the error committed by lowing the approximate rule. It will be seen that for angles less n 15° this error is always less than one degree.

	(1)	(2)	(3)	(4)
	1 in	1 in		
1°	57·29	60	58′	2′
2°	28·64	30	1° 55′	5′
3°	19·08	20	2° 52′	8′
4°	14·30	15	3° 49′	11′
5°	11·43	12	4° 46′	18′
10°	5·67	6	9° 27′	33′
15°	3·73	4	14° 2′	58′
20°	2·75	3	18° 26′	1° 34′
25°	2·14	2·4	22° 37′	2° 23′
30°	1·73	2	26° 33′	3° 27′
35°	1·43			
40°	1·19			
45°	1			

Explanation.—3° is actually 1 in 19·08; the approximate rule ves it 1 in 20; 1 in 20 is 2° 52′; error from following approx-ate rule 8′.

In Fig. 1 the dip along *AB* is 4° or 1 in 14·30, the dip along *A C* 15° or 1 in 3·73: *AB*=1430, *A C*=373, dropping the decimals. *D* is found to be 290. Hence the full dip is 1 in 2·9 or 19° very arly.

A. H. Green.

Leeds, *July* 13, 1876.

MR. MILNE ON FLOATING ICE.

Sir,—When comparing the altitude of an iceberg above water th the depth immersed, Mr. Milne has not sufficiently considered e conditions of stable equilibrum. A berg of the shape figured on ge 307 could not remain in that position, but must turn over. at this would be the case may be seen by placing a boxwood rahedron (out of a set of models of crystals) in water, where it ll float only with one of its *angles* downwards.

The position of stable equilibrium depends on the shape of the ating body, and on its specific gravity. The specific gravity of xwood being about 0·95, is so nearly the same as that of ice, that e positions assumed by a floating mass of either substance will as a le be almost identical.

O. Fisher.

THE OLDEST FOSSILIFEROUS ROCKS OF NORTHERN EUROPE.

Sir,—The evidence brought forward by Prof. Linnarsson in the ne Number of the Geological Magazine, as being opposed to the ews advanced by me, has been already disposed of to a great extent the papers in which these views have been propounded.[1] That of. Linnarsson is unable to put forward stronger evidence in op-sition to these views, is clearly a powerful argument in my favour, d I doubt whether he would have raised the objection at all had he gone over the papers still more carefully. In the paper first referred to I stated that in all the areas the first sediments thrown down on the old Pre-Cambrian land were either conglomerates, grits or sandstones, and which, being for the most part the result of a rather sudden encroachment of the sea on land, on which there was probably an abundance of loose material, would be heaped up rapidly. A period of rest would probably follow this rather sudden encroachment, and for a while fine sediments would be thrown down, not necessarily as the result of a very deep sea, but because all material would be washed off the exposed parts, and marine erosion on the hard rocks would yield but little sediment. In the Welsh areas we have evidence of several such successions in the sediments even in the Lower Cambrian epoch. The finer deposits being separated from each other sometimes by great thicknesses of sandy or gritty materials, showing the depression to have been great, and that a large land surface had probably been then submerged. From this it is clear that each depression would cause the first areas submerged to become more and more oceanic, and that each area also at one time or other must have been a shore-line. The fine sediments in the British area are of enormous thickness compared with those in Sweden, and that they were not heaped up rapidly is certain from the fact that the range of the species contained in them is often very limited indeed. The following table of the Lower Cambrian rocks will clearly show the several changes which took place at that time in the Welsh area, and the succession of the faunas:

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[1] Quart. Journ. Geol. Soc. vol. xxxi. p. 552 *seq.*; Geol. Mag. Dec. II. Vol. III. s. IV. V. VI.

	LOWER CAMBRIAN.	Thickness in feet.
1.	Conglomerates	60–200
2.	Greenish flaggy Sandstones	460
3.	Red fine-grained Shales or Slates affording the earliest traces of organic remains, viz. *Lingulella*, *Discina*, *Leperditia*, etc.	50
4.	Purple and greenish Sandstones	1000
5.	Yellowish-grey Sandstones, Shales and Flags, containing the genera *Plutonia*, *Conocoryphe*, *Microdiscus*, *Agnostus*, *Paradoxides*, *Theca*, *Protospongia*, *Discina*, *Obolella*, *Lingulella*	150
6.	Grey, purple and red Sandstones, alternating with Slates and Shales containing most of the above-mentioned genera (mostly new species)	1500
7.	Grey flaggy beds containing *Paradoxides Aurora*, *Conocoryphe bufo*, etc.	150
8.	The true beds of the "Menevian Group," for the most part calcareous Flags, Slates, and Shales, richly fossiliferous throughout, but chiefly in zones	600

Now, the only species which probably is common to the British and Swedish faunas in the Lower Cambrian rocks is *Paradoxides Forchhammeri* (*Hicksii*, Salter), and as this occurs high up in the Menevian group, and as each *Paradoxides* also has but a short range in the group, it seems reasonable to think that the *Paradoxides* schists in Sweden do not represent at the most more than the Menevian group. Hence, as there is no evidence of a previous fauna, it appears clear to me that this was the first fauna in that area after the first encroachment of the sea, for we have but one series of sandstones, and these are ripple-marked, showing shore conditions. If Prof. Linnarsson could but be brought to recognize this view of the gradual encroachment of the sea from a western or south-western direction over the European area, I am certain he would feel none of those difficulties which now occur to his mind, nor would he bring forward a fossil like *Dictyonema*, which has so extensive a range, to prove or disprove the correlation of certain beds. I look rather to the general order of the deposits, and the general character of the fauna, for a clue, than to one doubtful fossil, and it is on this ground that I still maintain that the Russian faunas are, as far as we can yet make out, Silurian in type, and not Cambrian.

As to the depression in the British area being dependent upon the volcanic action, I must remind Prof. Linnarsson again that we have no evidence of volcanic action having taken place until the Arenig period, or until after the area had been depressed to a depth sufficient to allow from 15,000 to 20,000 feet of undisturbed sediments to have been heaped up. Here his argument fails from mistaking the cause for the result. For volcanic action in this case was undoubtedly the result of the depression, and not the cause of it.

Henry Hicks.

AGE OF THE OTOTARA FORMATION.

Sir,—In the note by Dr. Hector, attached to Mr. H. Woodward's paper "On a Crab from the New Zealand Tertiary," I find the following: "From the comparison which this table affords with the recent fauna of the same area, the Ototara formation would seem to have no claim to a place among Eocene formations. This is confirmed by the occurrence of a few fossils of decidedly Cretaceous type, such as Saurian forms and fragments of the shell of *Inoceramus*, and the presence of many forms that are associated with decided Mesozoic fossils in the underlying strata."[1] In the table of formations given he makes the Saurians range up into the Ototara series, and in the section accompanying the note he also shows: "(*k*) Sandstones with Saurian bones, Ammonites, etc.," near Brighton.

The members present at the meeting seem also to have understood that Secondary fossils occurred in the Ototara formation; for in the discussion Mr. Charlesworth asked "whether the presence of the few Cretaceous fossils found in the deposit *which had furnished the New-Zealand Crab*," etc.

Now I wish to point out that no Cretaceous fossils have as yet been found in the rocks containing *Harpactocarcinus tumidus* and *Palæeudyptes antarcticus*; and I am not aware that any Cretaceous fossils or Saurian remains have ever been found on the west coast of the South Island. I have collected the fossils of the Ototara formation largely at Oamaru without finding any showing a Cretaceous facies.

F. W. Hutton.

Dunedin, *May 5th*, 1876.

"ESMERILO PRETO."

Sir,—Can you, or any of your readers, kindly inform me what was the origin of the pebbles "Esmerilo Preto?"

H. Lappington.

Padiham, Preston, Lancashire,
May 17, 1876.

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[1] Quart. Journ. Geol. Soc., 1876, vol. xxxii. p. 56.

GEOLOGY AND PALÆONTOLOGY OF SUMATRA.

SIR,—You will much oblige M. Verbeek by inserting the subjoined ERRATA and CORRIGENDA. T. RUPERT JONES.

STAFF COLLEGE, YORKTOWN, SURREY,
April 4th, 1876.

GEOL. MAG. 1875, New Series, Dec. II. Vol. II. (No. 136).

At page 478, lines 24–26, *instead of* "The lower siliceous schists," *read*, The lower portion consists of marl-slates and siliceous schists; the clay-slates with auriferous quartz-veins, which were formerly considered to belong to the Carboniferous period too, belong to another (older) period; but the age is not exactly known, no fossils having been found."

At page 482, line 26, *for* Caroe *read* Baroe.
" 483, in Fig. II. *for* Salok *read* Solok.
" " *for* Ampato *read* Ampalo.
" Fig. III. *for* Goenang *read* Goenong.
" 484, lines 9 and 22, *for* Singkorah *read* Singkarah.
" 485, line 10, *for* Goenoeng *read* Goenong.
" line 23, *for* Goeneng *read* Goenong.
" 486, line 4, *for* Capellan *read* Capellen.

Corrigenda for general list of *Erata for vol. for* 1876.

GEOL. MAG. 1876, New Series, Decade II. Vol. III. (No. 142).

At page 169, line 7, *for* Foraminiferæ *read* Foraminifera.
" 169, last line, *for* rensselorite *read* rensselærite.
" 171, line 29, for *Cannopora* read *Caunopora.*

THE CARRARA MARBLES.

SIR,—By way of postscript to the summary of recent views as to the age of these beds which appeared in the July Number of the GEOLOGICAL MAGAZINE, I beg to be allowed to mention the titles of the following memoirs, which bring the question up to the present date. These are:

1. Part ii. of M. Coquand's "Histoire des Terrains stratifiés de l'Italie centrale, etc." Part i. of which formed the groundwork of my *résumé.* This appeared barely a month since in the Bull. Soc. Géol. de France, sér. iii. t. iv. p. 126.
2. "Considerazioni stratigrafiche sopra le rocce più antiche delle Alpi Apuane" (Rome, 1875), by M. Carlo de Stefani.
3. "Un brano di Storia della Geologia toscana a proposito di una recente publicazione del S. Coquand" (Boll. del. R. Com. Geol. 1875, Nos. 5-6).

In the two latter papers the Italian geologist announces the discovery of fossiliferous limestones underlying conformably the saccharoidal marbles. The fossils are not specifically determinable, but they belong to the genera *Cerithium, Turbo, Rissoa,* and *Chemnitzia,* and with them are associated crinoidal remains. Professor Meneghini considers these fossils as being Triassic rather than Carboniferous, and M. de Stefani, doubtfully, adopts that view. M. Coquand, however, in paper No. 1, observes that the genera represented are Carboniferous as well as Triassic.

Since M. de Stefani himself regards the Triassic age of these beds as merely possible and by no means proven, and since also he admits a considerable portion of the series as undoubtedly Palæozoic, we shall probably not err in continuing to follow M. Coquand, and in still looking upon the statuary marbles as a whole as of Carboniferous age. Especially as other considerations also point that way.

LINTZ GREEN, NEWCASTLE-ON-TYNE,
6th July, 1876.

G. A. LEBOUR.

TRUE AND APPARENT DIP.—FLOATING ICE.

,—"The accurate rule" given by Mr. E. Hill, in the July er, Geol. Mag. p. 334, is, I believe, identical with that given e late Professor Phillips in his *Guide to Geology*, 5th ed. (1864), 8.

ilst writing, I may as well call attention to what appears to be print in Mr. J. Milne's paper, in the same Number. The ion "H = *h* = 1·080," p. 307, line 6 from bottom, should, I , be H = *h* × 1·080. W. Pengelly.

orna, Torquay, 5 *July*, 1876.

TRUE AND APPARENT DIP.

,—I am obliged to your correspondent, the Rev. H. G. Day, is remarks on my rules for finding the direction of true dip. aware that there would be a slight error arising from the ence between the circular measure of an angle and the tangent t angle, but in practice the former is much more readily adopted, he error is so small that generally it may be ignored.

friend, the Rev. O. Fisher, writes me, "Your rule *A* is correct nall dips for all practical purposes. It is not necessary that ngle between the faces of the quarry should be obtuse, the rule ually true whatever be the angle."

e modification Mr. Day proposes for rule *B* is an improvement; t would be better still, as Mr. Fisher had in the meantime sted, to measure off a line parallel to one face of the quarry pply rule *A* behind it,—adding, "you may step it on the ground ce, without making a diagram." W. H. Penning.

I. Geological Survey,
15th June, 1876.

BSENCE OF LLANDOVERY ROCKS IN THE LAKE DISTRICT.

,—I venture to think that Mr. Hicks's somewhat authoritative nent of Mr. Aveline's opinion—and Mr. Aveline's opinions are hastily formed—with regard to the absence of the Llandovery in the Lake District, appears a little out of place, when it is mbered that Mr. Aveline has spent nearly a lifetime among ocks of Wales and their equivalents in Cumberland, and that Hicks knows nothing of Cumberland, though he is justly ded as an authority upon many of the rocks of South Wales, g which he has worked so ably and successfully.

annot but think, also, that the fossil evidence, upon which so stress has been laid, must not be received unhesitatingly as ute. The presence or absence of certain Graptolites in these old is but imperfect evidence at the best, so little do we yet of the life-history of this group, and so much have recent sea discoveries shaken one's faith in the absolutism of palæ- ogical evidence.

d Mr. Hicks worked among the Cumberland rocks the number ars that Mr. Aveline and I have done, he would not perhaps found things so "tolerably clear" on comparing the districts of erland and Wales. J. Clifton Ward.

dale, *June 10th, 1876.*

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GEOLOGICAL SURVEY OF INDIA.—Retirement of Professor Oldham, C.B., M.A., LL.D., F.R.S., Director of the Geological Survey of India from 1851 to 1876.—We regret to announce the retirement, caused by ill health, of the Superintendent of the Geological Survey of India. During the quarter of a century that Dr. Oldham has held the appointment, since the Survey was first organized in fact, in 1851, the operations which he so ably guided have done nearly all that has been solidly effected towards the development of our Geological knowledge of the East Indies and Burmah; and the progress of the department has been well marked by the issue of the numerous publications—including the splendid Palæontologia Indica—a list of which has doubtless been often observed among our fly-sheets, and the parts of which have formed the subject of numerous Notices and Reviews.

Other geological work has been done, but of course the Survey results have been the largest as well as the most important, and independent observers have not sought the assistance of its chief in vain.

Having just completed the transfer of the very extensive collections, the library, etc., from the former Indian Geological Survey Office to its new quarters in the large Imperial Museum of Calcutta, he was obliged, from the recurrence of an attack which brought him home on sick leave within the last two years, to forego further labours in the East, leaving behind a staff of colleagues who have seen their long official connexion with him dissolved under these circumstances, with regret. The Indian Government has selected as his successor Mr. H. B. Medlicott, not much his junior in the service; under whose highly competent and energetic direction we may look for continued successful progress in the great work which the Survey has in hand.

Mr. R. B. Foot fills the vacancy in the upper grade caused by Mr. Medlicott's promotion.

Many friends will we know unite with us in trusting that Dr. Oldham may soon be restored to health, and long enjoy the rest which he has so amply and honourably earned.

GLACIAL DEPOSITS AT YORK.—Mr. J. Edmund Clark, 20, Bootham, York, writes us enclosing a series of photographs of sections of the Glacial drift exposed during recent excavations at the Railway works, York. Nos. 1 and 7 are particularly striking and full of interest. They are all good as photographs, but need a diagram or colours to explain the remarkable way in which some of the beds are folded and contorted. Mr. Clark writes:—"Mr. Monkhouse, Lendall, York, has photographed for me eight of the sections displayed at the Railway works in beds of glacial drift. They are cabinet-size, and clear; height of sections 3ft. to 8ft.

No. 1-4. Sand bed, inclined, contorted, with intercalated clays. Large scratched boulder *in situ*, in No. 1.
„ 5. Central sand bed, as anticlinal, against which lean 1-4 on E. and 6 on W.
„ 6. Beds of sand, boulders, and pebbles, in layers to W. of 5.
„ 7. Angular mass of sand, among boulders and pebbles.
„ 8. Pebble heap, assorted by current; false bedding."

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE II. VOL. III.

No. IX.—SEPTEMBER, 1876.

ORIGINAL ARTICLES.

I.—The Climate Controversy.

By Searles V. Wood, Jun., F.G.S.

THE cause of changes in Climate during past Geological periods having lately become, and being likely to continue, a prominent pic of interest, I have attempted here to bring together the more ominent features in the controversy, under the idea that to many aders, who have not either the time or the inclination to more osely examine the subject, this may be acceptable. In so doing I ve, with one partial exception, confined myself to discussing the fficulties which beset all the various theories offered as a solution, ther than attempted the advocacy of any one of those theories in rticular.

The following seven causes have been advanced, at various times, account for the changes in Climate, which the evidence of the ological record proves have taken place during that portion of e Earth's history which it covers.

1. A decrease in the original heat of our planet.
2. Changes in the obliquity of the ecliptic.
3. The combined effect of the precession of the equinoxes, and of e excentricity of the Earth's orbit.
4. Changes in the distribution of land and water.
5. Changes in the position of the Earth's axis of rotation.
6. A variation in the amount of heat radiated by the Sun.
7. A variation in the temperature of those regions of space through hich the solar system has moved.

No. 1.—Since all physicists are agreed that the earth has underne a process of cooling, the main questions that have arisen under is head are: what has been the effect of this cooling upon the nperature of the earth's surface, and whether evidences of such frigeration can be traced in the Geological record?

As to the first of these questions, a celebrated physicist is of inion that the influence of the earth's proper heat on climate is t only inappreciable at the present day, but must always have en so since the condition of the crust allowed of the existence of e upon the earth. As to the second, it must be admitted that ganic remains throw but little light upon it. Beyond the fact that the present day reptile-life cannot exist in very cold climates, and ems to prevail in the direct ratio of the warmth of the air or water which it lives, there is but little to show that the climates of those earlier periods in which that form of life abounded were warmer than the climates of the Tertiary group. So far as the lower types of animal-life and the remains of vegetation furnish evidence, the climate of Northern Europe during both the Eocene and Miocene periods would seem to have been as warm as that of any preceding period. Though so little evidence is thus, however, afforded by organic remains, there is one fact that seems to me to bear upon the subject which I have not seen alluded to, and it is this, viz. the effect of increased heat over the earth's surface generally would, as is well known, produce increased rainfall, and, as a consequence, more rapid atmospheric denudation; more sediment, that is to say, would be carried down by rivers to furnish the material for sedimentary deposits accumulating around continental areas. Now if we compare such groups of rock as the Silurian with Tertiary groups, we are struck with the smaller amount of change presented by the forms of organic life in any given thickness of sedimentary deposit, in the case of the older, than in the case of the newer formations; and, *ceteris paribus*, this would raise a presumption that sedimentary deposit proceeded more rapidly during the earlier Geological periods than it did during the later.

No. 2.—It is obvious that no alteration in the obliquity of the ecliptic would affect the quantity of heat received from the Sun by the Earth as a whole. The effect, whatever it may be, would be confined to the distribution of this heat in latitude. There appears to be a unanimous opinion among astronomers up to the present time, that the utmost limit within which the inclinations of the planes of the equator and ecliptic to each other can vary is less than a degree and a half;[1] a quantity that seems too little of itself to have affected climate to any great extent, whatever be the correct view as to the kind of alteration which such variation would produce. Nor would a decrease in the obliquity remove the difficulty offered by long seasons of continuous night, which some geologists consider irreconcilable with the fossil vegetation of Spitzbergen, unless it were so great as to bring the plane of the equator to within a very few degrees of that of the ecliptic. Spitzbergen, lying in latitude 80° North, and the sun taking just the same time for its passage from the equator to the tropics, whether the obliquity be great or small, the winter of Spitzbergen would not be very materially shortened, unless the Arctic circle were brought to at least half its present distance from that country. If, however, we suppose this to occur, the obliquity being reduced from its present amount by as much as one-third, it would still leave Spitzbergen far within the Arctic circle; and its light-receiving position even then would only be about the same which that part of Greenland lying between the 74th and 75th parallels of latitude now occupies. Such a reduction the obliquity, therefore, although it would take those parts of eenland near Disco, about latitude 70°, in which a similar fossil getation is preserved, out of the Arctic circle, and consequently t of the limits within which darkness for any lengthened period evails, would not remove the difficulties presented by the Spitz-rgen vegetation in any appreciable degree.

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[1] Sir C. Lyell, in his "Principles," states, however, that Sir John Herschel informed him, that although the limit calculated by Laplace (1° 21′) was true as regards the last 100,000 years, yet if millions of years were taken into account, it was conceivable that the variation might be found to extend to three, or even four *degrees.*

Two writers, Colonel Drayson and Mr. Thomas Belt, have lately ged that the Glacial period proper was due to an increase in the liquity of the ecliptic; but Mr. Croll insists that, instead of an rease of cold during the year in high latitudes, or even an rease of winter cold balanced by a corresponding increase of mmer heat resulting from an increase of obliquity, the effect of ch increase would be to augment the warmth of the polar climate a whole, by reason that the further the sun receded from the uator, the more heat he would during summer impart to high itudes at the expense of low ones, while the cold of winter would t be materially aggravated in high latitudes by his greater reces-n on the opposite side of the equator; and he quotes Mr. Meech's lculations to prove that the poles would, when the admitted liquity was at its maximum, receive during the year nineteen rays r every eighteen which it receives at the present time. It seems to e, however, notwithstanding this, that there is some fallacy lurk-g in the contention that the winter cold would not be augmented an increase of obliquity to the same extent that the summer heat ould be. Moreover, if the reasoning which Mr. Croll uses to ove that there is a cumulative tendency in the formation of ice d snow, and consequently of cold, in relation to the Excentricity eory which he advocates, be sound, is it not equally applicable to e Obliquity theory? and inasmuch, therefore, as the area of the lar circles, or the area in which ice and snow form and remain ring winter, would be increased by a greater obliquity (and this a larger degree than the obliquity itself), would not the effect of at increased area, by the cumulative process, make itself felt in a neral refrigeration of climate? If so, then, by parity of reasoning, diminution of this area of cumulative cold, by a decrease in the liquity, should produce amelioration of climate. There will be casion to recur to this subject of the accumulation of cold in nsidering the cause No. 3. Taking the view he does, however, as the effect of an increase in the obliquity, Mr. Croll attributes uch influence to it, in combination with the cause to which he fers the greatest influence on climate—the varying excentricity of e earth's orbit; and he contends that, assuming that the astrono-ers are right in limiting the variation in the obliquity to about 22′ on each side of the amount at which it stood at the beginning the present century, a concurrence of the maximum of this bliquity with the maximum of excentricity would probably cause rest-trees to grow at the pole of that hemisphere which had the n in perihelion during winter.

No. 3.—The cause suggested under this head is the one which, uring the past few years, has produced the greatest amount of discussion, and therefore demands the most examination. More than thirty-five years ago, M. Adhemar advanced a theory that the Noachian deluge was the last of a series of deluges which had occurred during past ages from the melting of snow and ice accumulated at that pole which lay in the hemisphere where the aphelion, or point of greatest recession of the earth from the sun, occurred during winter. It has long been known that, owing to the phenomenon called the precession of the equinoxes, the aphelion and perihelion points are transferred from the summer to the winter seasons, and *vice versâ*, every 10,500 years or thereabouts;[1] so that for this period the sun is at its greatest distance from the earth during the winter season of one hemisphere and the summer season of the other; while for the next 10,500 years these conditions are reversed. M. Adhemar contended that the effect of this would be, that during the occurrence of the aphelion near the winter solstice of either hemisphere, the polar ice of that hemisphere would be constantly augmenting; and that as the perihelion point returned to the winter season of such hemisphere, this accumulated ice would be dissolved, and great volumes of water be liberated. In 1866 Mr. Croll revived this theory, in so far as it assumed to account for changes in climate, and added to it the effect which would be produced by the varying excentricity of the earth's orbit, in either increasing or diminishing this refrigerating power of the aphelion; according as by increased excentricity the aphelion was removed further from the sun, or by diminished excentricity was brought nearer to it.

Many objections have been offered to this theory. One was that, whether the excentricity be great or small, an equal quantity of heat is received by the earth during every revolution round the sun: the augmented distance of the aphelion being balanced by the diminished distance of the perihelion during increased excentricity, and *vice versâ;* so that the augmented heat of the 10,500 summer seasons, due to the occurrence in them of the perihelion, would balance the refrigerating effect of the occurrence during the same number of years of the aphelion in the winter season, and melt all the extra quantity of ice that the increased winter cold had produced; the result being merely that the difference of temperature between winter and summer would be greater or less, according to the position of the aphelion and the degree of excentricity.

It seems, however, that this is not precisely true; but that the quantity of heat received by the earth from the sun in every revolution round it varies inversely as the minor axis of the orbit; which would make the quantity of heat received greatest when the excentricity was greatest, and *vice versâ*; thus diminishing any effect produced by an increase of excentricity in augmenting the cold of mid-winter in that hemisphere in which the aphelion occurred at this season.

It is also admitted that whatever be the variation thus arising from the length of the minor axis, each hemisphere receives an equal quantity of heat during any one year; the greater contiguity of the sun in perihelion being compensated by the more rapid motion of the earth in its orbit at that time, and *vice versâ*.

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[1] It appears that this period of 10,500 years is subject to large variations; but it is convenient to speak of it as of that duration.

Mr. Murphy has, since this theory was first advocated by Mr. Croll, endeavoured to show that the occurrence of the aphelion points during the winter season would have the opposite effects to those attributed to it by Mr. Croll; and that it is to the occurrence of the aphelion in the summers of either hemisphere during periods of great excentricity that the glaciation of such hemisphere is to be attributed. Mr. Murphy has lately brought forward another paper, in which he seeks to establish this point; but as it is not yet published, I shall avoid the chance of misrepresenting his views in the mean time by confining myself to merely calling attention to them.

Mr. Croll admits that the position of the aphelion point would not, of itself, produce any sensible effect on climate, even with the maximum of possible excentricity, which he gives as making a difference between the sun's distance in aphelion and perihelion of 14,212,700 miles; but he contends that when the cumulative tendency of ice and snow and the operation of the great ocean currents are taken into consideration, the true and principal cause of the changes which have occurred in climate has been the combined operation of the position of the aphelion and the varying excentricity of the orbit.

As regards this alleged tendency of ice and snow to accumulate at the pole of that hemisphere near the mid-winter of which the aphelion point occurred during periods of a high degree of excentricity, Mr. Croll argues that the increased heat of the sun in summer, due to the corresponding occurrence of the perihelion at that season, would be neutralized by the absorption and reflection by ice and snow of a large part of the heat so received, and by the creation of fogs which would intercept the rays. With respect to absorption, Mr. Croll argues that 142° Fahr. are absorbed in melting one pound of ice, and completely lost, so far as raising its temperature is concerned, by reason that they are consumed in tearing asunder the molecules against the forces of cohesion which bind them together into the solid form. Is not an equal quantity of heat, however, liberated to raise the temperature of the surrounding air when congelation returns? With respect to the rays reflected, Mr. Croll does not tell us what becomes of them. They must, it is to be assumed, be absorbed by the atmosphere; but in what way the icy region is prevented from indirectly receiving the benefit of them, when so absorbed, he does not attempt to show.

With respect to the fogs, Sir Charles Lyell urged that there were no sufficient data to assume, as Mr. Croll did, that the intensity of the sun in a clear sky, which would first melt the ice, would afterwards be sufficiently overcome by fog to check and almost prevent further melting, in spite of the continued supply of excessive heat during summer; but Mr. Croll has since collected instances of the prevalence of snow storms and fogs in the Arctic and Antarctic regions, and endeavoured to show that it is to these causes the snowclad condition of Sandwich Land and the South Georgian Isles—lying in latitudes corresponding, respectively, to the North of Scotland and centre of England—is due. In reference, however, to the interception and absorption of the sun's rays by the creation of fogs, are we not entitled to assume that, since vapours give out in condensation an amount of heat equal to that absorbed in their creation, compensation would be thus afforded, and all the heat intercepted by fogs be eventually restored to the atmosphere of the icy region?

To argue that cold produces ice and snow, and that these again aggravate the cold, and so, by reacting on the cause, tend to produce a continual accumulation of the effect, does to many minds seem arguing in a circle. This Mr. Croll admits, but contends that the argument is none the less sound. He does not, however, pursue his argument to that extent which carries conviction to my mind, but leaves it with an impression that, notwithstanding all that is urged, the agencies to which is attributed a cumulative tendency in ice and snow contain within themselves forces that exactly, but in a less obvious form, compensate for the effects which are attributed to them.

From a mean of temperatures taken north and south of the equator,[1] it appears that the temperature of the surface of the whole earth is greater when it is in aphelion than when it is in perihelion. This was attributed by Sir Charles Lyell to the heating effect of the great body of land lying in the northern hemisphere—that body of land being exposed to the summer sun while the earth was in aphelion. Mr. Croll, however, regards it as a necessary result of his theory, attributing it to the loss of heat during perihelion, caused by the southern and more glaciated hemisphere being then turned towards the sun, and part of its heat lost by the agencies just discussed.

Another and the most important of the causes operating to give influence to the excentricity is, according to Mr. Croll, the great oceanic circulation, in carrying heat from equatorial to temperate and polar regions; and he has entered into an elaborate examination of the subject to prove that the heat thus transferred is far greater than is generally supposed. He also contends that the position of the aphelion greatly influences the direction of these currents. His argument is too long to summarize; but in the case of the Gulf-stream, for instance, his contention is that with the main configuration of the great continents unaltered, this stream, instead of flowing as it now does, would during the glaciation of the northern hemisphere, begin so much further south in mid-Atlantic that, instead of entering the Gulf of Mexico and being thence deflected north-eastwards to Northern Europe, it would be deflected by the coast of South America southwards, as in fact one part of it now is deflected. This alteration Mr. Croll deduces from a previous hypothesis which he seeks to establish, viz. that the refrigeration of the northern hemisphere which would arise from the occurrence of the aphelion in its winter, would push the equatorial belt of calms some degrees of latitude further south, and with it the north-east trade, to which he insists the Gulf-stream is due. In reference to this oscillation of the equatorial belt of warmth, Mr. Croll quotes the adoption by Mr. Darwin of the Excentricity theory as accounting for the diffusion of certain species of plants, which occur alike in the temperate, but not in the tropical regions of both the northern and southern hemispheres. The view is, that as the cold of the northern hemisphere became greater, some of the more dominant and wide-spreading northern temperate forms invaded the equatorial lowlands, and as the two hemispheres gradually recovered their former temperature, that then, although most of these northern temperate forms so living in equatorial lowlands would have been driven to their former homes or destroyed, some of them would have ascended any adjoining highland, where they would have survived like the Arctic forms on the mountains of Europe. Then, as the southern hemisphere was in turn subjected to a severe glacial period with the northern hemisphere rendered warmer, the southern temperate forms would invade the equatorial lowlands to intermingle with the northern forms so left on the mountains, but from which they now descended. As the warmth again increased, these southerners would return to their former homes, leaving some species on the mountains, and carrying southward with them some of the northern temperate forms which had descended from their mountain fastnesses.

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[1] I am not aware on what observations these temperatures are based; but if they were taken at land stations exclusively, or preponderatingly, the fact alleged to result from them may not be free from question.

The necessity for this complex explanation is not apparent, at any rate so far as the continent of America is concerned; as all that would seem necessary for the passage of temperate forms of plants from north to south, and *vice versâ*, is a line of mountains running in that direction of elevation sufficient to induce on their flanks or summits temperate climates in tropical latitudes; and this, if we make allowance for the proportionate refrigerence of all latitudes during the glacial period, we find on the American continent; since those parts of the chain which now, in Central America, do not from their small altitude furnish this condition of things, would have had at that time temperate climates on their flanks or summits, and the intervals of hot lowland have been so reduced as not to prevent the occasional migration of temperate climate plants from one hemisphere to the other. On the other hand, the common origin of the Greenland blubber whale (*Balæna mysticetus*), and the right whale of the Antarctic (*Balæna australis*) at a late period, which has been generally admitted is repugnant to that oscillation of the equatorial warm water belt without curtailment of its breadth, which forms part of the Excentricity theory; and seems to indicate that a curtailment of the breadth of this belt, which now forms so impassable a barrier between these allied species, did actually take place by means of that simultaneous refrigeration of both hemispheres which all the facts hitherto observed in reference to the Glacial period proper appear to me to prove.

The theory that the oceanic currents are due to the action of the trade winds is old, but the intimate connexion which Mr. Croll shows to exist between the general oceanic and atmospheric circulations is very striking. The influence, however, of these currents, except so far as their direction may be supposed to be altered by the alternate glaciation of the two hemispheres from the position of aphelion, is applicable equally to theory No. 4. To that theory, however, and to the one under consideration, there arises the objection, so far as the Glacial period proper is concerned, that the distance to which the evidences of glaciation extend southwards on the eastern side of North America, beyond what they do in Europe, seem to indicate that the portion of the oceanic circulation to which the existing differences in climate between corresponding latitudes in Europe and North America are due could not have differed much during that period from what obtains now.

The theory requiring that there have been many periods of high excentricity, during every one of which there were one or more minor periods of about 10,500 years when the opposite hemispheres were subjected to the alternate conditions of glaciation and warmth, Mr. Croll endeavours to prove by two things. One of these is that glacial periods embracing such minor periods of alternation have occurred at different stages in the Geological record; and the other, that the evidences preserved of that particular period which we are accustomed to call the Glacial afford proof of there having occurred during its progress repeated alternations of climate, or, in other words, interglacial periods of warmth. As to the first of these, he has (as Sir Charles Lyell has, as regards some of the instances, also done in his "Principles") collected various notices by geologists of formations considered to be indicative of ice action, belonging to Silurian, Devonian, Carboniferous, Jurassic, Cretaceous, Eocene, and Miocene ages respectively; and they no doubt to some readers have a very convincing appearance; but to others they induce more perplexity than conviction. In my own case, not being so familiar with the Palæozoic and Mesozoic formations as with the Tertiary, I read these instances of Palæozoic and Mesozoic glaciation with respect, though not conviction; but when I come to the Eocene and Miocene instances, facts clashing entirely with them present themselves. In the case of the Eocene, we are offered the evidence of the occurrence, in the unfossiliferous Flysch of the Alps, of a bed containing blocks of all dimensions up to the size of an ordinary church; and in the Miocene the evidence of a North Italian bed containing blocks both of large dimensions and striated. Now the Eocene formation is complete in England, and is exposed in continuous section along the north coast of the Isle of Wight from its base to its junction with the Oligocene (or Lower Miocene according to some), and along the northern coast of Kent from its base to the Lower Bagshot Sand. It has been intersected by railway and other cuttings in all directions and at all horizons, and pierced by wells innumerable; while from its strata in England, France, and Belgium, the most extensive collections of organic remains have been made of any formation yet explored, and from nearly all its horizons, for at one place or other in these three countries nearly every horizon may be said to have yielded fossils of some kind. These fossils, however, whether they be the remains of a flora such as that of Sheppey, or of a vertebrate fauna containing the crocodile and alligator, such as is yielded by the beds indicative of terrestrial conditions, or of a molluscan assemblage such as is present in the marine and fluvio-marine beds of the formation, are of unmistakably tropical or subtropical character throughout; and no trace whatever has appeared of the intercalation of a glacial period, much less of successive intercalations indicative of more than one period of 10,500 years glaciation. Nor can it be urged (though this would be the contrary of what is urged in relation to the Glacial period proper, in which the warm intervals are regarded as accompanied by terrestrial conditions, and the cold ones by submergence) that the glacial periods of the Eocene in England were intervals of dry land, and so have left no evidence of their existence behind them, because a large part of the continuous sequence of Eocene deposits in this country consists of alternations of fluviatile, fluvio-marine, and purely marine strata; so that it seems impossible that during the accumulation of the Eocene formation in England a glacial period could have occurred, without its evidences being abundantly apparent. The Oligocene of Northern Germany and Belgium and the Miocene of those countries and of France have also afforded a rich molluscan fauna, which, like that of the Eocene, has as yet presented no indication of the intrusion of anything to interfere with its uniformly subtropical character. It can hardly be contended that the mollusca adapted themselves to a refrigerated sea, and again to a warm one, without the facies of the fauna being changed, because we find during the succeeding period, the Pliocene, the molluscan fauna gradually changing by the disappearance of the tropical and subtropical genera, and by the incoming of species which now generally inhabit Arctic and Boreal seas, thus indicating the gradual approach of those climatic conditions which culminated in the Glacial period.

When it is suggested that at two distinct epochs during this uninterrupted prevalence of tropical and subtropical conditions in England and adjoining countries, glaciers descended to the sea several degrees further south, we can scarcely escape the admission that if they did so it could not have been in consequence of any cause involving the existence of the present axis of rotation; for neither lofty land nor ocean currents could have modified the climate of Switzerland or North Italy to such a degree as to allow glaciers to descend to the sea there, while countries lying several degrees of latitude nearer the pole were enjoying a tropical climate. The only thing clear about these so-called Eocene and Miocene glacial beds is that we have much to learn about them!

As to the other fact which is essential to the Excentricity theory, viz. the occurrence during the Glacial period proper of alternations of 10,500 years warm climate, we find no indication of any such alternations during that gradual refrigeration which is indicated by the change in the Pliocene mollusca before referred to; but this objection Mr. Croll would no doubt meet by his contention that the periods of warmth would be necessarily those of emergence, or, more accurately, of a recession of the sea due to the attraction of the Southern ice-cap; and that it is only the periods of gradually increasing refrigerence (which would be those of submergence in Northern Europe, owing to the transfer of the ice-cap to the northern hemisphere) which the Pliocene mollusca would record. The value of this contention our present certain knowledge of Pliocene land deposits renders it difficult to test by reference to facts, that knowledge being almost confined, in the case of Western Europe, to the Cromer Forest-bed, and the lacustrine formations of the Arno valley; but so far as these cases go, they seem to show no appreciable departure from the kind of climate indicated by the marine deposits of nearly similar age; and afford no support to the idea that they accumulated during intervals of warmer climate. As regards such intervals during the Glacial period itself, Mr. Croll has collected together a number of notices brought forward by geologists, which he considers prove his case. Most of these refer to discoveries in Scotland; but as it appears to me that some of the deposits which are treated by Scotch geologists as Glacial belong to the period which, in reference to English deposits, we are accustomed to call Post-Glacial, during the latter part of which period there occurred, in my opinion, some degree of renewed refrigeration and a partial submergence, it may be convenient to summarize the conclusions to which a study of the English Glacial and Post-Glacial formations has led me; more particularly as Mr. Croll has connected one of the instances upon which he relies to prove these warm intervals of the Glacial period with my name.

In the first place, I have long contended that the English Glacial beds, inclusive of the unstratified clays, are of marine origin; and I believe that the gentlemen of the Geological Survey employed in the examination of these beds have mostly come to a similar opinion. We have in England an advantage in possessing the sequence of Glacial formations more complete than they are in Scotland, the earlier members of the series being, according to my view, unrepresented in the northern portions of Britain; and throughout this series, from its commencement, with beds lying in juxtaposition to the Crag, and differing but slightly in their molluscan fauna from the latest members of the Crag series, to its termination in the shelly gravels at high elevations in Lancashire, and at Moel Tryfaen, there is, with one doubtful exception, nothing that I can discover indicative of a cessation either of Glacial climate or of marine conditions. This exception refers to the unconformity that I discover between the Lower and Middle Glacial deposits of East Anglia, which appears to me to be very marked, and to have been connected with the principal excavation of the East Anglian valley-system. Unfortunately there is nothing yet found to prove that this valley excavation was the result of a conversion of the Lower Glacial deposits into land; and though we may infer that the excavation of valleys is more probably due to terrestrial agencies than to marine, it is not impossible that powerful currents, issuing from beneath the termination of the land-ice, may have been the agent of the excavation in question. Connected with the same subject is the age of the Pakefield mammaliferous deposit and forest-growth, for this deposit and growth is, while demonstrably newer than the Crag (which that on the Cromer coast is not), so dissociated from the Lower Glacial formation, though overlain by the Middle, that it is quite possible it may be of interglacial age; and if it could be proved so, would go far to establish that the interglacial valley excavation of East Anglia was due to terrestrial agencies, as well as that this terrestrial condition was accompanied by a climate which supported a growth of the forest-trees whose trunks I have seen at Pakefield. This, however, is only a possibility; and as such is the only break, either in climate or continuity of marine conditions, that I can discern in the Glacial sequence in England. It also appears to me that Scotland, with the northern parts of England, formed together an ice-centre (or possibly several ice-centres) quite independent of, and detached from, the Scandinavian and all other ice, unless it were, perhaps, that of Wales and Ireland; and that gradually, as the northern and mountainous parts of the island became enveloped by land-ice, the whole of Britain underwent depression, this depression extending in the northern part and in Wales to 1500 feet, or more, below the present level, but diminishing southwards and eastwards, so that most of France continued above the sea. The southern portion of England, with the exception, perhaps, of a few of the most elevated hills which had then come into existence, was thus covered by the sea; but this was barred out of the northern portion and out of Scotland by the enveloping land-ice, the material produced by the degradation of the formations on which this rested travelling out beneath it to the sea, carried *at the bottom* of the bergs as they broke off, and dropped (sometimes in large masses) over the contiguous sea-bottom. Thus, omitting from consideration the lower division of it, in consequence of the uncertainty attending the break before referred to, the rest of the Glacial formation of England indicates to my mind the gradual recession of this land-ice towards its centres, the formation following that recession, and having its sequence partly in the vertical, but much more in the horizontal direction, by reason of its having accumulated principally in contiguity to the land-ice, and having, in following up its recession, occupied the place left vacant by it. By this process the mountainous parts of our island eventually assumed the condition of a snow-capped archipelago, when the gravels and sands of Moel Tryfaen, Macclesfield, and other elevated districts, were deposited, and finally the ice and snow disappeared and emergence took place. It was not, as it seems to me, until after this emergence, which we are accustomed in England to regard as marking the commencement of the Post-Glacial period, or during its progress, that Britain became again inhabited by the great mammalia. Looking at the presence of such fluviatile mollusca as *Cyrena fluminalis* and

Unio littoralis, and of such mammalia as the *Hippopotamus*, and other great pachyderms, and of such a littoral Lusitanian fauna as that of the Selsey bed, where it is mixed up with the remains of some of these pachyderms, as well as of some other features, such as that of the Lexden bed,[1] it has seemed to me that the climate of the earlier part of the Post-Glacial period in England was possibly even warmer than our present climate; and that it was succeeded by a refrigeration sufficiently severe to cause ice to form round all our coasts, and glaciers to accumulate in the valleys of the mountain districts; and that this increased severity of climate was preceded, and partially accompanied, by a limited submergence, which nowhere apparently exceeded 300 feet, and reached that amount only in the northern counties of England. To this refrigerence, it seems to me, the Hippopotamus early succumbed; but the other pachyderms struggled on, eventually to succumb to it all over Europe and North Asia, so that they all co-existed, more or less, with the Arctic mammalia. I do not recollect having met with any notice of the coincidence, but it has struck me as significant, in reference to the view that the pachydermata thus owe their extinction to Post-Glacial refrigeration, that it is for the most part those Post-Glacial mammalia which all palæontologists admit to be specifically different from their living representatives, which are represented by inhabitants of warm climates; whereas, on the opposite hand, those Post-Glacial mammalia that are specifically identical with living forms are represented by inhabitants of climates where there is a considerable degree of winter cold.[2]

To the extent thus explained there seem to me to have been alternations of climate in England connected with the close of Geological time, whether we call them Glacial or Post-Glacial, Tertiary or Post-Tertiary; but they do not appear to be precisely such successive alternations of hot and cold periods, accompanied during the latter by general submergence, as the Excentricity theory demands.

Proceeding on this assumption that during periods of great excentricity the hemisphere in which the aphelion occurred during winter would not only be glaciated, but be subject to submergence, in consequence of the attraction of the ice-cap drawing the sea towards it, and away from the opposite hemisphere, where it produced emergence, Mr. Croll endeavours to show that the Coal-seams of the Carboniferous formation are due to interglacial periods of warmth. His view is that during these warm periods, when the land emerged by the sea being drawn away from it, a very equable climate prevailed in consequence of the sun being, while the excentricity was at its extreme limit, upwards of fourteen million miles nearer to the earth during the winter of the favoured hemisphere than during its summer, so that the seasons would approximate in temperature; and that then grew the vegetation of the Coal-seams, which is generally admitted to indicate an equable rather than a tropical climate. With these warm periods alternated the cold ones, due to the transference of the perihelion from the winter to the summer, during which the attraction of the ice-cap drew the sea over the coal-growths, which were thus covered by submarine sediment, to emerge again at the return of the perihelion, and form the site of a new growth of vegetation; and so on successively as the perihelion changed, until the period of high excentricity, giving rise to these alternate conditions, passed away. The ingenuity of this hypothesis can hardly be denied; but if its basis is sound, we ought to find not merely conglomerates and other beds at distant localities occasionally presenting features supposed by some to indicate ice-action, but the very Coal-measures themselves which separate the successive Coal-seams in this and other countries, and which are thus referred to intervals of glaciation and submergence, invariably abounding with evidences of ice-action. We have not, however, yet heard of this being the case. Indeed, Mr. Croll, anticipating this objection, endeavours to explain it, on the ground that the Carboniferous land was too low and flat to allow glaciers to form; and that for the same reason there would be no rocky cliffs to supply boulders for coast-ice to transport and distribute. Considering, however, that the Silurian system had been upheaved and penetrated by eruptive rock before the Carboniferous period, and that yet older rock-masses than the Silurian had been also for ages in existence, and these at no great distance from the Coal-fields of Britain, such an explanation demands larger concessions than most geologists will be willing to grant.

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[1] The insect remains from Lexden, one of the numerous Post-Glacial brick-earths of England, were considered by Mr. Wollaston to indicate a warmer climate than our present one.—Q. J. G. S. vol. xix. p. 399.

[2] For the grounds of the views thus summarized see papers in the following, viz. Quart. Journ. of the Geol. Soc. vol. xxiii. p. 394, vol. xxiv. p. 146, vol. xxvi. p. 90, vol. xxvii. p. 3; Geol. Mag. Vol. VII. pp. 17 and 61, Vol. VIII. p. 406, Vol. IX. pp. 153, 171, and 352. I hope at a future time to explain in more detail the evidence indicative of the Post-Glacial submergence referred to in the text, which is that to which the Hessle Clay of the North-East, and the Upper Boulder-clay of the North-West of England are in my opinion due.

Finally, in reference to the suggested cause now under consideration, it is obvious that if the Glacial period proper was due to the position of the aphelion point, the northern and southern hemispheres could not have been synchronously glaciated; but as the evidence stands at present, this synchronism in glaciation would seem to have been the case. It was a principal object of the expedition made by Louis Agassiz in the year 1872, to examine how far the evidences of former glaciation remaining in the more southern parts of South America lent any support to the theory of alternate glaciations of the two hemispheres; but he could find nothing in any way leading to the inference that the southern glaciation was not absolutely contemporaneous with the northern;[1] nor has anything, so far as I am aware, been brought forward in reference to the evidences of glaciation furnished by New Zealand that would lead to any different conclusion. Similarly, so far from the features exhibited by those formations of very high latitudes in which are preserved the remains of a rich arboreal vegetation lending any support to the theory that the much warmer climate than the present to which this vegetation was due was interrupted by intervals of intense glaciation, as it is suggested was the case during the Eocene and Miocene periods in Switzerland and Italy, Professor Nordenskiöld has been unable, in successive visits to Spitzbergen, to discover in the well-exposed and thick succession of Miocene deposits of that island, so rich in plant-remains, any traces of a bed presenting evidence of ice-action.[1]

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[1] Report of the progress of the Hassler Expedition, in *Nature* for August 1, 1872.

(*To be continued in our next Number.*)

II.—On *Eubrochus clausus*, a Vitreo-hexactinellid Sponge from the Cambridge "Coprolite" Bed.

By W. J. Sollas, B.A., F.G.S., Assoc. R.S.M.

(PLATE XIV.)

AMONGST the undescribed sponges from the Cambridge "Coprolite" bed, which have come under my notice, is the beautiful hexactinellid that forms the subject of this communication.

An almost complete specimen and a well-preserved fragment of the sponge are to be seen in the Woodwardian Museum; a good specimen has been placed in the Geological Survey Collection by Mr. Jukes-Browne; and I once saw another in the cabinet of Mr. Buxton, Trin. Coll., Cambridge. Besides these, I have only met with a few smaller fragments, and thus the species would seem to be somewhat a rare one.

Pl. XIV. Fig. 1 represents the specimen in the Woodwardian Museum, natural size; outwardly it resembles a short stout club, or a vase in which the sides have curved together so as to obliterate the mouth, and thus to form a continuous roof over the cavity they inclose. Mr. Jukes-Browne's specimen is very similar to this; but a short process (Fig. 2 *c*), diverging from the summit, seems to indicate that his was a branching form, while the Museum specimen is certainly single.

The bases of the specimens are somewhat worn, so as to make it impossible to determine whether the sponge was sessile or not in habit.

The surface is covered with a network of fine linear depressions, looking like narrow grooves scored into the substance of the phosphatic material of which the fossil is composed. These lines are the inner half of hollow casts, the outer half of which has been worn away by gentle attrition on the sea-floor, and they represent the fibrous network which once constituted the dermal skeleton of the sponge. The network thus indicated covers not only the sides of the fossil, but its summit also, completely surrounding it, like the net which incloses a balloon.

Its constituent fibres cross one another approximately at right angles, and so form a square meshwork, which closely resembles that of *Farrea occa* (Fig. 3). The centres where the fibres cross and fuse into one another are $\frac{1}{100}$ of an inch apart on the average, and consequently the meshes of the net are each about $\frac{1}{100}$ inch long on each side.

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[1] Geol. Mag. 1876, Decade II. Vol. III. p. 266.

Mr. Carter[1] has shown that the siliceous "fibres" of the *Vitreo-hexactinellidæ* are produced by the cementation of a number of hexactinellid spicules together by a coating of siliceous matter: and in fact that just as acerate spicules are imbedded in keratose fibre to form the skeleton of such sponges as the *Chalinidæ*, so hexactinellid spicules are imbedded in siliceous fibre to produce the rigid skeletons of such forms as *Farrea, Aphrocallistes, Dactylocalyx, Euplectella,* and their allies; and it naturally follows from this, that so long as the sexradiate spicules retain their rectangular tri-axial forms, the fibres built upon them will present, wherever a spicule occurs, a similar regular sexradiate knot; and what appear to be points of intersection of three crossing fibres are really points where the six arms of a spicule regularly radiate. Thus, in the sponge under consideration, each rectangular intersection of the linear depressions represents the place where siliceous fibre once formed upon the four arms of a sexradiate spicule at right angles to one another; the other two arms are invisible, one because it passes directly into the "coprolite," the other because it, in common with the outer half of the cast of the fibres, has been worn away while the fossil lay exposed on the sea-floor.

The network arising from the union of the spicules might be very irregular, if the latter were dispersed without any arrangement, as, for example, in *Dactylocalyx* (Stutchbury); if, however, they be grouped according to a general plan, a very regular network may result, as in *Farrea occa,* and the dermal reticulation of the sponge under consideration. In the latter the fibres exposed on the surface can be arranged in two groups, as will now be described.

At the base of the sponge are four nearly equidistant centres, from which the fibres regularly radiate. Starting with one of these centres, we may trace a set of fibres passing from it, and diverging from one another as they go; the more medial fibres of the group ascend the side, cross directly over the summit, and descend on the opposite side; those which lie nearer the sides of the group simply curve round the sides of the sponge; but all agree in finally converging to the centre facing their point of origin. Thus all these fibres are simply loops of different lengths and obliquity connecting two opposite centres.

The fibres from the other pair of centres are disposed in exactly the same manner, and the two sets of loops thus come to be placed at right angles to each other, and so to produce a regularly rectangular meshwork. This is well shown in the accompanying woodcut, which is a map of one side of the Museum specimen; it is not drawn to scale, and only professes to be accurate so far as it shows, in the area represented, every fibre and the intersection of every fibre in their true relations. The fibres from the centre 'A' may be observed on the left passing in curves towards the centre 'C,' which is here only obscurely indicated, and as they do so, the fibres which curve in a similar way from 'B' to 'D' may be seen to intersect them. Those fibres which ascend from 'A' to *a*, or from 'B' to *b*, cross right over the top of the sponge and join 'C' in the former, or 'D' in the latter case, on the opposite side of the sponge.

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[1] *Ann. and Mag.* Nat. Hist., vol. xii. pp. 48–49.

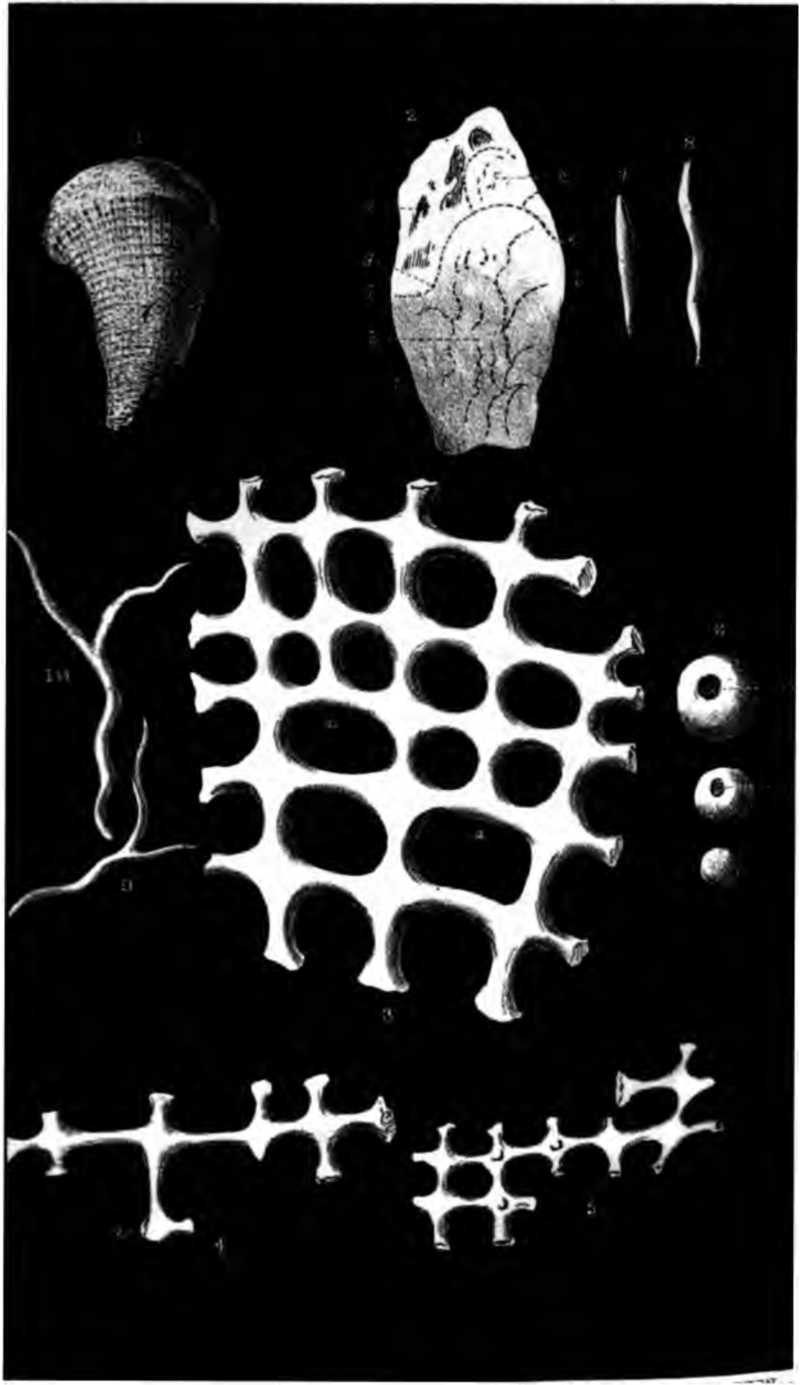
Diagram-plan of the fibres in *Eubrochus clausus.*

If this were all, it would happen that as the curving fibres diverged from one another, the spaces between them would continually enlarge, and the meshes of the net would get bigger and bigger the further they were from the basal centres. This, however, is prevented by the appearance, wherever the divergence has become considerable, of fresh fibres (Pl. XIV. Fig. 3 *a*, and woodcut), and thus the meshes are kept of tolerably constant size.

The younger fibres so introduced are of less diameter than the primary ones, as is shown by the fact that their casts do not score so deeply into the coprolite, hence the fibres would seem to have grown thicker with age.

The characters we have just described are quite sufficient by themselves to distinguish the sponge, and I now propose the name *Eubrochus clausus* for it; *Eubrochus* on account of its fine meshwork, and *clausus* because its interior cavity is quite closed.

With a view to making out the internal structure of *Eubrochus*, the broken face of the fragment in the Woodwardian Museum was carefully ground down and polished several times, so as to obtain sections at different depths. When examined with a one-inch objective by reflected light, patches of lattice-like tissue and sexradiate knots were to be seen here and there in the matrix, but no regular and continuous network like that which appears on the exterior. From this one could not decide whether the sponge possessed any other skeleton in addition to the single layer of meshwork which forms its dermal reticulation, since the few fragments of sexradiate structure observed in the interior might possibly have been washed in from without during the process of fossilization; in order, therefore, to determine this point, I obtained permission to cut



De Wilde lith.

Eubrochus clausus, Sollas. "Coprolite Bed".

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the specimen which Mr. Jukes-Browne had collected for the Survey, and which he had kindly lent me. Two transparent slices were prepared from this, one cut along the length of the fossil and the other at right angles across it; both showed the hexactinellid network in the form of empty hollow spaces in the solid coprolite; the original fibres of the skeleton have completely disappeared, leaving behind mere empty casts, which are sometimes perfect sexradiate spaces, and at others have entirely lost their original shape, and show no trace of the form on which they were modelled. Pl. XIV. Fig. 2 is a sketch of the longitudinal section, natural size; in colour it is light brown, but greenish where glauconite has permeated it near the exterior; transparent, especially so along the edges, but with opaque patches in its midst, probably consisting of the chalky silt in which the sponge was at one time imbedded. The part marked '*a*' is coprolite which has incrusted the original fossil, '*b*' is the main body of the sponge, and '*c*' a process or bud which has sprouted out from one side above. The network of the exterior, which completely incloses the sponge, is indicated at the sides '*l*' '*l*' by notches, which are empty or filled with phosphatic material stained by glauconite. At the top the coating of coprolite has better preserved the outer meshes, and so along the line '*d*' to '*e*' these are well exhibited as an interrupted series of hollow sexradiate casts. At '*g*' the centre of one of these sexradiates may be seen to give off a radius which passes to the centre of a second inner sexradiate element (Fig. 4 *a*); this alone indicates clearly that the skeleton of the sponge did not consist of a single layer of meshwork merely, and points moreover to a connexion between the dermal reticulation and that interior network which we shall now show *Eubrochus* to have possessed. Throughout both the longitudinal and transverse sections open spaces occur, which in some places are without definite form, but at others appear as clusters of distinct hollow sexradiate casts (Fig. 5). They are not scattered at random, but arranged along certain irregular curved lines, which appear to radiate from the base of the sponge upwards, in such a manner as would result if the sponge in growing left the exterior network of one stage to become the interior of the next. The sexradiate casts are in all cases simple, and never complicated by the addition of the characteristic octahedral 'lantern' which surrounds the 'knots' in *Myliusia Grayi* and in the Ventriculites.[1] Thus *Eubrochus* was evidently a solid sponge provided with an interior skeleton of the same simple structure as its superficial reticulation.

In the sections we have just described appear also a number of simple acerate spicules $\frac{1}{100}''$ to $\frac{1}{160}''$ long (Pl. XIV. Fig. 7), and certain serpentine bodies, which are more like contort spicules than anything else; but their irregularity in form, occasional branching, and variation in size, seem to show they are not so (see Pl. XIV. Figs. 8, 9, 10). As to their real nature I am ignorant, as I am also of that of certain minute round bodies which occur with them. The round bodies are almost perfect spheres, hollow, with a circular foramen;

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[1] H. J. Carter, F.R.S., Ann. and Mag. Nat. Hist. ser. 4, vol. xvi. p. 76.

and now and then I have seen a small solid central sphere inside, looking like a nucleus. In size they vary from $\frac{1}{250}''$ to $\frac{1}{1000}''$ (Pl. XIV. Fig. 6); they are often amber in colour when viewed with transmitted light, and they appear to be soluble in acid, though it is difficult to make this out with certainty in the case of such very small bodies imbedded in a chalky matrix, which is itself soluble with effervescence in the same solvent. Possibly they are single detached chambers of *Foraminifera*, like *Globigerina* or *Nodosaria*, both of which occur in the sections along with Greensand casts; but the abundance of these round bodies, out of all proportion to the number of the *Foraminifera* associated with them, their perfect shape, and complete isolation, would seem to negative such an idea, and half incline one to look upon them as independent organisms. I mention them here because both they and the contort branching bodies before referred to occur very commonly in the ordinary so-called "Coprolites" of the Cambridge bed.

As regards the position of *Eubrochus* in our classification, it clearly belongs to the *Hexactinellidæ*, since in no other sponges do we find the same rigid adherence to a sexradiate type. The existence of hollow casts only in the place of the original skeleton might appear at first sight difficult to reconcile with the view that the latter was composed originally of siliceous material; but here we are no worse off than in the case of the Ventriculites preserved in a phosphatic matrix, in which there has occurred a similar disappearance of fibres, of whose original siliceous nature there can now be no manner of doubt, since their characteristic structure and arrangement have been discovered, in all their details, in the vitreo-hexactinellid *Myliusia Grayi.*

Having then placed our sponge amongst the *Hexactinellidæ*, we must assign it to that family of the order in which the skeletal spicules are united together into a rigid continuous network (*Vitreo-hexactinellidæ*), instead of being merely connected together by sarcode (*Sarco-hexactinellidæ*).

A closer determination of the alliance of *Eubrochus* is very difficult to make, especially as the rosettes, and other forms of flesh spicules which characterize the *Hexactinellidæ*, are entirely absent; that they once existed may be regarded as highly probable, and their disappearance can excite no surprise, since the processes of solution which have destroyed the coarser fibres of the skeleton would inevitably remove every trace of these more delicate structures. The dermal reticulation might be expected to furnish some clue, and, indeed, it closely resembles in the squareness of its meshes the single layer of lattice-like network which constitutes the skeleton of *Farrea occa. Eubrochus* differs widely from *Farrea*, however, in the fact that its external reticulation forms a complete inclosure to an interior skeleton, while in *Farrea* a single layer of harrow-like network simply forms an empty tube open at the mouth. The resemblance with *Farrea*, then, is solely in the rectangular meshwork of the dermal reticulation, and the value of this for classificatory purposes is very doubtful, since Dr. Bowerbank has recently described a square-meshed sarco-spiculous network which covers the surface of perfect specimens of *Euplectella aspergillum*, and Mr. Carter has suggested to me that we may now expect to find a similar, but vitreo-spiculous, network coating the surface of many of the *Vitreo-hexactinellidæ*. Perhaps the first instance of this has been found in *Eubrochus* in the fossil state, and considering this possibility and the absence of marked internal characters in our new sponge, it will be well to wait for further investigations before coming to any conclusion as regards its generic affinities.

VITREO-HEXACTINELLIDÆ.

Eubrochus clausus, mihi.

Sponge, clavate, solid, sessile (?), simple or branching.

Skeleton, a network, originally siliceous, characterized by sexradiate knots, filling the interior, and forming on the exterior a rectangular meshwork.

Distribution, Cambridge, Upper Gault, *remanié* in coprolite bed at the base of the Chalk-marl. (*Note.*—On the back of the tablet on which the Museum specimen is mounted I find a note by Mr. Seeley, stating that the form also occurs in the Red Chalk of Hunstanton.)

EXPLANATION OF PLATE XIV.

Fig. 1. *Eubrochus clausus*, Woodwardian Museum, natural size.

Fig. 2. Longitudinal section of Mr. Jukes Browne's specimen, natural size; (*a*) coprolite encrusting the exterior; (*b*) principal part of the sponge, with dotted lines to indicate the course of the internal fibres; (*c*) rudimentary branch; (*d* to *e*) exterior network preserved by the encrusting coprolite; (*g*) position where indications of the connexion of the dermal reticulation with the interior fibres are to be seen, shown magnified in Fig. 4; (*l l'*) lateral margins.

Fig. 3. Dermal reticulation of Fig. 1, showing at (*a*) the appearance of new sexradiate elements. (× 25.)

Fig. 4. Part of the network extending along the curved line from (*d*) to (*e*) of Fig. 2, showing centre of inner sexradiate at (*a*). (× 25.)

Fig. 5. Finer network from the interior of Fig. 2. (× 25.)

Fig. 6. Spherical bodies of various sizes; (*a*) circular foramen. (× 100.)

Fig. 7. Acerate spicule from Fig. 2. (× 100.)

Figs. 8, 9, 10. Curvilinear and branched bodies like contort spicules. (× 10C.)

III.—Ice and Ice-Work in Newfoundland.

By John Milne, F.G.S.,

Professor of Geology in the Imperial Mining College, Tokei, Japan.

(*Continued from the August Number, page* 350.)

Coast Ice of Newfoundland.—Icebergs have an advantage over coast-ice in their imposing appearance, which has perhaps been in part instrumental in raising them to the high position which they now occupy as workers of Geological changes. Many Manuals of Geology, and many diagrams drawn to illustrate the same science, have oft-times portrayed a well-known flat-topped berg, carrying a rock, in the Antarctic regions; but neither books nor lecture-diagrams, taken collectively, give any adequate idea of coast-ice as a similar agent. From what I have seen of coast-ice and of its effects, I feel persuaded that it is an agent of at least as great, if not of greater universality than either glaciers or icebergs, and taken as a whole perhaps also as an agent of equal power. Of the various forms of sea-ice known as "berg-ice," "floe-ice," "pack-ice," and the like, the portion I would more particularly draw attention to is that variety which forms a narrow belt along the shore, known in Greenland as the "Ice-Foot."

It would appear that in the formation of the "Ice-Foot," just as in the precipitation of rain, and in the production of other natural phenomena, we may have either one or many causes called into operation. Sometimes these may all be equally active, whilst at other times the rôle taken by one cause is more important than that taken by another, all being governed by circumstances. Geikie, in "The Great Ice Age," pp. 67 and 68, tells us that the Ice-Foot of Greenland "owes its origin to the action of the tides." "The first frost of the late summer covers the sea with a crust of ice, which, carried upwards along the face of the cliff by the tide, eventually becomes glued to the rocks." It thus "grows in thickness with every successive tide, until it may reach a height of 30 feet, and sometimes even more, presenting to the sea a bold wall of ice, against which the floes grind and crush."

In Newfoundland and the South Coast of Labrador, although the formation of the Ice-Foot is no doubt oftentimes very similar to this, there are yet other agents, besides that of the tide, which are equally active.

First we will imagine this formation taking place on a gently-sloping shore.

The Ice-Foot.—The blasts of December and January drive the *spray* high up upon the land, and there it freezes as a cake of ice;

day after day and night after night this continues, and the crust grows thicker. A drift or fall of snow may help it in accumulating, until it is at last from two to three feet in thickness. Stones of all sizes, from pebbles to boulders, on which this coating may rest, are now firmly set in "an icy maw" of ice, and are ready at the first movement to cut and grind a path for themselves. The first calm weather the sea freezes out from this to form an equivalent to the "bay-ice" of the Greenland whalers. This, however, is only a thin coating, which is either broken up or piled upon itself by the first rough water coming from the "outside," or is driven off by a land breeze. This generally goes on until some portion of the Northern pack, coming south, meets with an adverse wind and is driven ashore. When we reflect upon the immense mass contained in one of these moving fields of ice, we can hardly conceive the energy that is stored within it. Everything has to give way before it, and the coast-ice, with its set of gravers firmly bedded in its base, is pushed high and dry, sometimes as much as 100 yards, back from high-water mark.[1] It is in this way, by the coming in of the Northern Pack, the rise and fall of the tide, and other causes, that the land-ice is driven ashore, and many of the scratches and grooves so common round the coast of Newfoundland have been made. As a rule, these markings are remarkable for their definition. Some of the scratches are so parallel, so long, and so like each other, and even in their character from end to end, that at first sight their origin might be doubted. Markings like these may be well seen in the harbour of St. John's Island. The rock in which they are impressed is a Calciferous Limestone, sloping gently seaward. It looks as though it had been planed perfectly flat, and then a series of parallel lines several yards in length, from three to six inches apart, and from $\frac{1}{8}$ to $\frac{1}{4}$ of an inch in depth, had been evenly ruled across the prepared surface. Sometimes, instead of these lines crossing an even plane, similarly-marked smooth trough-like hollows have been formed. These increasing in size in places give quite an undulating character to the shore, as at the entrance to Terra Nova River and elsewhere.

Such a piling up of ice by the driving in of the pack, whether it be inland or ashore, is amongst the sealers termed "raftering." At a certain distance out from land, where the pack-ice can float, it breaks off from that which is cemented to the shore. This latter, no matter how it may have been formed, whether by spray or piled-up pack-ice, goes under the general name of "balacada." It has been suggested to me that this term, like many Newfoundland names, may have its origin from the Spanish, it being a corrupted form of "barricado," a name very suggestive of the appearance and conditions it is intended to describe. The edge of the "balacada" is termed the "drain," which may average a depth of about four fathoms, up and down, while through the agency of wind and tide a continual chafing action is going on.[1] If the pack-ice can float up and down along the foot of a cliff, or in deep water near rocks, the consequences are the formation of horizontal grooves and scratches, and these in cases are carried to such an extent that the cliff may be undercut. The "balacada," in a position of this sort, is formed by the spray, and projects out a foot or two from the face of the cliff; the drain, with its floating-ice, being beneath.

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[1] In the selection of Arctic papers for the Arctic Expedition of 1875, published by the Royal and Royal Geographical Societies, p. 49, Robert Brown speaks of sheet-ice and boulders during storms being driven and packed to a height of 50 feet.

In addition to the work done in scratching and grooving by the coast-ice, it also does much in the transportation of material. When in deep water, chafing along the face of a cliff, by its own horizontal and vertical movements, together with its continued force of impact on a heaving swell, it must detach a considerable amount of material. This, together with that which may fall upon its edge from the rocks above (which appear to be universally greater at the breaking up of a frost than at any other season of the year), is carried by the coast-ice to a new home. The chief agent, however, in the transportation of material is the "balacada," barrier-ice or ice-foot, attached to the shore. At low water this freezes to the ground on a shelving shore, and is at once firmly attached to both boulders and stones. When the tide rises, this ice, with its cargo, floats, and may be carried away. The difference in level between neap- and spring-tides is another cause which greatly accelerates the transporting power of the "balacada." A land breeze assists in the dragging off of portions that are only partially aground. These, with other causes, are always, during the winter season, more or less in operation in removing materials from one point to another.[2]

This immense transportive power of the coast-ice often occasions severe losses to the fishing population of Newfoundland and Labrador. Various articles, to remove which would involve considerable difficulty, such as anchors and cables, having been left upon the beach, have been carried off by the ice;—it has come along, and after, so to say, glueing itself to everything upon the the shore, has floated off with all to which it was attached. At three harbours, Tilt Cave, Englee, and Goose Cove, I heard lamentations over losses of this description; and no doubt, upon inquiry, similar cases might be recorded of every fishing settlement both in Labrador and Newfoundland. The fishermen seem to have transferred the name "Anchor Ice," from its original idea of ice which anchors itself to the bottom, to ice of this description which endangers the equipment of their vessels. Without actually freezing beneath the surface of the water, as in some of the shallower parts of the Baltic where ground-ice is formed, a species of anchor-ice is formed by the freezing of the "balacada" so firmly to the ground at low water, that at the rising of the tide it remains beneath the surface of the water. The consequence of these transportive movements is that much material, both boulders and pebbles are carried out to sea, and then deposited in a manner similar to that which has so often been explained in the case of icebergs. Another consequence is that similar materials are carried from point to point along the coast, and on the disappearance of the ice are left as monuments of its former existence. In places boulders may be seen lining the shores in long lines, like tiers of barrels on a wharf, as at Change Island. Boulders of this sort are referred to, and a sketch of them is given, in Lyell's Principles of Geology, vol. i. p. 381. I have here spoken irrespective of the immense quantities of boulders that are annually brought down attached to the "ground-ice" of rivers.

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[1] The grating against vertical cliffs is referred to in De la Beche's "Geological Observer," p. 280, and at p. 282 on coast-ice generally.

[2] Speaking of the Greenland Ice-Foot, Geikie, in his "Great Ice Age," p. 68, says that "during summer vast piles of rock and rubbish crowd the surface of the ice-foot." "To such an extent does this rock-rubbish accumulate that the whole surface of the shelf is sometimes buried beneath it, and entirely hidden from view." "Along the part of the coast of Greenland where the ice-foot is shed at the end of every summer, the quantities of rock débris thus borne seawards must be something prodigious."

Movements of Coast-Ice.—On the first calm day the ice out at sea along the edge of the pack commences to break up, and small lakes and pools are formed between the pans. This appears to be due to the tide. In a calm five square miles of ice will rapidly open out and spread over 20 miles, during which it is greatly smashed about and tumbled. Capt. A. Jackman, to whom I am indebted for many facts regarding the action and formation of coast-ice, informed me that on one occasion he knew of two vessels closely wedged in the ice, which were separated 20 miles apart in one night during a calm. A wind from seawards only jams it the tighter on the land, whilst one from the shore sends it off in a body until there is sufficient water between it and the land, where a sea can form, upon which the ice is speedily dispersed. In calm weather the pack travels with the current, but at other times it follows the direction of the wind. Icebergs, on the contrary, although affected by the wind, have a more definite direction in their line of travel dependent on currents. The consequence of this would appear to be that the line of distribution of material derived from pack-ice is not so definite in its direction as that of icebergs. In both cases the proportion of the mass exposed above water to that which is submerged is equal. The explanation therefore appears to lie mainly in the fact that the pack only rests on the upper surface of the water, which is affected by the wind, whereas the iceberg, descending to greater depths, will move in a steady current unaffected by any such surface disturbances. The ratio of the surface exposed above water to that beneath it in the pan of ice, to that in the berg, must oftentimes also be influential in the explanation of this phenomenon. Should a berg be entangled in a pack, and the tide be contrary to the wind, the berg may hold its own against both the wind and pack, and, so to speak, will force for itself a passage. Capt. A. Jackman has, whilst frozen in the pack, travelled at the rate of from two to three knots per hour past bergs, but whether these were aground or not was not definitely stated.

Conclusions regarding Coast-Ice.—As before remarked, it would appear that coast-ice might at least be considered as an agent in the production of Geological changes equal in power to either glaciers or icebergs.

By this it is not wished to imply that a mile of coast-ice is equivalent to a mile of glacier, but rather that coast-ice, taken as a whole, from the extent of its area, may be reasonably compared as a modelling and disintegrating agent of our globe with either the glaciers or icebergs.[1]

Looking at the Northern Hemisphere only, and comparing all the deeply indented coast-lines, say that of North America and Greenland, every yard of which is more or less subject to the action of coast-ice, with the portions throwing off glaciers to form bergs, it will be seen that the coast-ice must in quantity be infinitely greater than the glaciers. All the vast ice-fields which break loose from the frozen regions of the North, and we read of them 300,000 square miles in extent, and seven feet in thickness, are, in their passage South, driven in upon the land, and help to grind the coast-line and transport its boulders. The Northern field-ice, when it arrives in the latitudes of Newfoundland, is often seen to be covered with boulders, gravel kelp, and other materials, showing it to have been at some time or other in contact with the coast. Ice of this description is well known to the sealers, who carefully avoid it, knowing that seals will not be found upon "dirty jam." From this, together with other information I collected, it would seem that, amongst the inhabitants of Newfoundland, the action of coast-ice as a transporting agent is universally recognized, whilst icebergs in the same latitudes are seldom seen with earthy materials upon them. Capt. A. Jackman, during about 30 years of ice-service on the coast of Newfoundland and Labrador, only once saw a mass of stone of any size upon a berg, whilst coast-ice, with its load of material, has continually been met with. That this should be the case appears on consideration to be evident; for at the outset, when the berg leaves its parent, the glacier, in these Northern regions, it has but little moraine matter to carry,[2] whilst afterwards the winds tending to drive it in upon the shore seem to affect it but little.[3] Now and then it may disturb the strata, and perhaps carry off a portion of the material forming some bank on which it has happened to ground, but to approach the land, as coast-ice does after leaving its birth-place, it is for ever debarred. Carried along by a deep-sea current, with but little care for wind or wave, it cleaves a course through ice and water to more southern regions.

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[1] Although it may be said that glaciers are not alone confined to Arctic regions, but are also to be seen in the highlands of more temperate climates, it must not be forgotten the distance south that coast-ice is found along shores like those of Labrador, Newfoundland, and Siberia, where glaciers are unknown.

[2] "Owing to the inland valleys (of Greenland) being filled up and levelled to the tops of the hills, there is well-nigh a total absence of those long trains of débris that thunder down the steeps of the Alpine Mountains, and gather in heaps along the sides of the glaciers."—Geikie, "The Great Ice Age," p. 62. Dr. Rink, however, saw moraines above Upernivik.

[3] It might be argued that the bergs carry a burden of rocks and débris frozen to their bases; but in Geikie's "Great Ice Age," p. 61, we read:—"A few stones may occasionally remain frozen into the bottom of the detached iceberg, but it is evident that the greater portion of the sub-glacial deposit must remain at the bottom of the sea," and at p. 71 we read: "By far the larger number of Arctic icebergs therefore contain no extraneous matter, and melt away in mid-ocean without leaving behind them any record of their voyage." However it would be unfair not to quote from the observations of Robert Brown (Quart. Journ. Geol. Soc. 1870, p. 687), who states that on ascending an iceberg he "almost invariably found moraine which had sunk by the melting of the ice into hollows, deep out of sight of the voyager sailing *past.*"

The work done by a glacier is slow and steady. On its surface it carries all that may fall upon it, whilst at its base it annually smoothens for itself deeper and deeper the rocky bed on which it rests.

When floating-ice is pushed ashore, we have a somewhat similar action; but in addition to this steady pressure, coast-ice has another mode of acting which is wanting in the glacier, viz. that of impact. A faint conception of what this is may be derived from the accounts we read of Arctic travel. "The growling and roaring," "the crash of meeting floes and fields of ice," "the broad fields of ice several hundreds of miles in area broken up into countless floes," "the hummocks and hills that are piled up under the tremendous pressure," have all been spoken of.

Scoresby gives a calculation of the blow which must be produced by one of these immense fields of ice which he mentions, as being equal to that of 10,000,000,000 tons. Now all these tremendous blows delivered by ice-islands floating down upon each other must be given in a similar manner to a rocky coast.

After once seeing the broken masses of the icy "pavement" of these Northern regions scouring along by cliffs and islands, jostling and cannoning with all it meets as it rises and falls on the heaving swell, one cannot help being impressed with the immense amount of work that it is capable of performing.

Possibility of a sequence in Ice-Action.—It has now been shown how coast-ice may, to a certain extent, give a character to a coast-line; how it may, by impact, remove all asperities, and how, by a steady pressure, it may groove and scratch, and even produce a surface not unlike the *roches moutonnées* of the glaciers. We will now consider whether those markings may be reasonably expected to remain as permanencies.

In Newfoundland, which appears to be a rising area, there is every reason to suspect that many of the markings seen round the coast, which have hitherto been attributed either to glaciers or icebergs, have been impressed by coast-ice. Whatever the iceberg may have done when the now dry surface was beneath the sea, on emergence must in all probability have been obliterated, and the surface remodelled by the action of the coast-ice. A striking instance of this modelling of what is probably a rising area is seen at Funk Island. This island lies almost 30 miles out in the Atlantic to the East of Newfoundland. It is about half a mile in length, very low and flat, and is situated right in the stream of the Arctic ice. The northern end of the island, which has every year to face this tremendous pressure of vast fields of ice, is visibly worn down and covered with erratic boulders; whilst the opposite extremity is a low but abrupt cliff. Had the flow of ice been from the south, the reverse would probably have been the case, and the low shelving wedge-like shore, which forms a slide for the ice to mount together with its load of boulders, would have been at the opposite extremity of the island. On a rising area of this sort the impressions that have been made appear certainly to affect in a permanent manner even the contour of the island, and it does not seem unreasonable that scratches and boulders may in a rising area be similarly preserved. Should the rising area be in a climate like that of Greenland, the effects of coast-ice would in time be planed away by glaciers. If the area be a sinking one, the results may be reversed. The surface configuration of the land, whether produced by glaciers or other causes, will be remodelled by the coast-ice, and these in their turn, on reaching deeper water, will be affected by the icebergs.

Looking at the effects of ice-work in this way, we see that there is a possibility of a sequence in their action. In high latitudes, where the climate is a constant one, the sequence is definite. Should the climate, however, be variable, we might have a surface scoured by icebergs, and covered with debris not emerging from the sea, uutil a warmer temperature had dissipated the icy pavement that once floated, and in this way we might see the effects of icebergs in the modelling of a land-surface.

THE END.

IV.—Fossil Fish in North Devon.[1]

By Townshend M. Hall, F.G.S., etc.

THE recent discovery of fossil fishes in the Carboniferous beds of North Devon appears of sufficient importance to require that the facts connected with it should be placed on record.

In the first place, it is necessary that I should give a short summary of what was known down to the end of the first week of July, 1876, regarding the occurrence of fossil fish throughout the northern division of the county.

(1.) The Lynton, or Lower Devonian group affords remains which have been referred to *Steganodictyum*, as well as fragments of fish bones in considerable quantities.

(2.) The Middle Devonian, near Ilfracombe, contains fish spines, bones, and coprolites; but owing to the absence of scales and teeth, it is impossible to determine the genera to which they belong.

(3.) In the Upper Devonian, at Baggy Point, a scale of *Holoptychus* was described and figured by Professor Phillips in 1841.[2]

(4.) In the Carboniferous formation, as far as I am aware, there has been no single instance of fish remains, with the exception of a doubtful fragment resembling a portion of a scale, found by me some years ago at Venn Quarry, near Barnstaple.

[1] Read before the Devonshire Association for the Advancement of Science, Literature, and Art, Ashburton Meeting, July, 1876.

[2] Palæozoic Fossils of Cornwall, Devon, and West Somerset, p. 133.

Proceeding to the south and east Parliamentary divisions of the county (which, for geological purposes, it is more convenient to unite under their old name of South Devon), the Carboniferous rocks appear to be equally destitute of fish. In "The History of the Discovery of Fossil Fish in the Devonian Rocks of Devon and Cornwall," by Mr. W. Pengelly, F.R.S.,[1] reference is made to a paper read in 1843 by the Rev. D. Williams, before the Royal Geol. Society of Cornwall,[2] in which the following passage occurs: "Mr. Parker, jun., late of Exeter, found a beautiful tooth in the Posidonia Limestones of the Coddon Hill grit series, at Doddiscomb Leigh, north of Chudleigh, which Professor Owen pronounced to belong to a genus of fishes hitherto found only in the Urals." In answer to my inquiries, Mr. Pengelly has been so kind as to inform me that, besides the above extract, he knows of no published notice of fish remains in the Carboniferous formation of any part of Devon or Cornwall.

In several of the other Carboniferous areas, both in England, Scotland, and Ireland, fish are not uncommon, whilst in Belgium they are extremely rare; the unequal distribution of their fossil remains resembling, in fact, what may be observed with regard to the habits of modern species. An entire absence of fish in the Carboniferous series of Devonshire would probably have afforded but little surprise to any one who had studied the conditions under which the rocks have been formed, and the contortions to which they have been subjected. The equivalents or representatives of the Coal-measures, Millstone-grit, Mountain Limestone, and Carboniferous shales, which together occupy the area from Dartmoor, on the south, to Barnstaple, on the north, have afforded only 46 species of fossils, out of which number, as will be seen by the following table, no less than 26 belong to the Vegetable Kingdom.

Actinozoa	1	*Cephalopoda*	6
Brachiopoda	5	*Echinodermata*	3
Lamellibranchiata	4	*Plantæ*	26
Nucleobranchiata	1		—46

To these I have now the pleasure of adding a fish of the genus *Cœlacanthus*, and have also obtained evidence, from scales, of two other species as yet undetermined. The honour of the first discovery is due to Mr. W. Porter, of Pilton, who on July 7 presented me with a portion of a Carboniferous nodule, containing a fish measuring 6·25 inches from the end of the snout to the extremity of the caudal fin, and 1·85 inches in breadth. The scales are covered with minute striæ.

I at once submitted the fossil to Mr. R. Etheridge, F.R.S., who informs me that it is nearly allied to *Cœlacanthus granulosus*, Agassiz, from the Permian beds of the North; whilst the scales resemble those of *C. elegans*, Newberry. Unfortunately there are no teeth visible, nor pectoral fin. It may safely be called a new species.

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[1] Trans. Devon Assoc. vol. ii. pp. 425, 426.

[2] Trans. Royal Geol. Soc. of Cornwall, vol. vi. pp. 122, 138.

The nodule was found at Instow, in one of the clayey beds traversing the Carboniferous grits, which here occupy a nearly vertical position. I have often worked in the same locality, and during the last ten years have obtained a great number of similar nodules; but, so far, had never known them to contain any other fossils besides *Goniatites*, *Streptorhynchus crenistria*, *Spiriferæ*, and plant-remains. However, on a careful re-examination of these specimens, I detected scales belonging to the same fish upon four different fragments of rock, and on removing more of the stone, found beneath the surface scales of two other species.

A continuation of the search will, no doubt, afford further results, and I trust will enable me to describe and figure these new fossils.

NOTICES OF MEMOIRS.

I.—NOUVEAU BASSIN HOUILLER DÉCOUVERT DANS LE LIMBOURG HOLLANDAIS.—[ON A NEW COAL-FIELD IN DUTCH LIMBURG.]—A privately printed Report, by Prof. G. LAMBERT, of Louvain, dated March, 1876. Two Maps and a Plate of Sections. Abstracted and Translated by G. A. LEBOUR, F.G.S. London and Belgium.

"IN the early days of Coal-mining in Europe those portions only of the Coal-measures were made use of which cropped out at the surface, or were not overlain by more recent formations. As by degrees these portions have become exhausted, the workings have been extended beneath the newer rocks.

"It is thus that in Westphalia, Belgium, Northern France, and the North of England, the Coal area worked or known is now ten times what it was fifty years ago.

"Especially of recent years has the increase in the price of coal given rise to the most active and successful researches and explorations.

"Hence the formation of a great Coal-mining centre in the Department of the Pas-de-Calais, in France. Hence also the splendid discoveries which have been made in the northern part of the Ruhr basin. In this basin, towards the north, a new Coal-bearing zone has been determined and entered upon, not less than 15 kilometres in breadth, and to which no northern limit has yet been found. On the contrary, it appears as if the thickness and regularity of the seams increased as the workings gradually advance in that direction.[1]

"The increase in thickness towards the north of the beds overlying the Coal-measures delays the establishment of collieries in this new Coal-field.

"Fortunately, these beds belong almost exclusively to the Lower Cretaceous, and consist of unctuous clayey marls, which hold very little water, are easily worked, and do not fall in; so that pits five metres in diameter can be sunk to the Coal-measures, *i.e.* 200 or 300 metres in depth, at less cost than has been incurred for several shafts of from 50 to 100 metres in the 'couchant' district of Mons—sunk through much-fissured and open chalk, and especially through the bands of flints, with much water, which are never absent from the lower part of this chalk in Hainault.

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[1] At present the breadth of this Coal-basin already proved, measured along the meridian passing through Bochum, is of about 50 kilometres.

"In the northernmost part of this new zone, and in the neighbourhood of the River Lippe, the Tertiary sands overlying the Cretaceous rocks, and the Permian Magnesian limestones which seem to occur there, will probably offer great difficulties in pit-sinking. It is, however, scarcely necessary to trouble oneself on this head, since the more easily-attainable portion is sufficient to meet the requirements of many years to come." . . . . .

[Here follows a reference to some Sections given in a Plate appended to the Report. These Sections illustrate the structure of the Coal-fields of the Ruhr, of Theux, and of Durham. A Section taken from a well-known English paper shows the Coal-fields of Canobie and Plashetts, and from the context it would appear that the author regards the latter as of Coal-measure age. This is a mistake; the Coal-seams of North-west Northumberland belonging, it need scarcely be said, to the Carboniferous Limestone series.]

"A striking fact is revealed by the examination of these three sections, and by a study of the three great basins to which they relate, viz. that in these three basins the southern portion of the Coal-measures is much contorted by pressure in every direction exerted upon them during, or soon after, their formation, and prior to the deposition of newer beds.

"It follows that the southern limit of these basins is very irregular, and that at certain points lateral basins are found branching off from the principal ones, or even small circumscribed isolated basins.

"To the north, on the other hand, as is shown by the Sections of the English and French basins, there is great regularity, apparently increasing in that direction, as does also the richness of the basin.

"This fact is of great importance with regard to future explorations at points lying between these Sections; for wherever the known portions will show much dislocation, numerous changes, and high angles of dip, it will be well to explore the northern part to a great distance, in order to see whether the principal regular basin does not lie in that direction.

"From this point of view Dutch Limburg, and probably also Northern Belgium, are favourably situated for the discovery there of the prolongation of the Coal-measures.

"It is admitted that the Belgian Coal-measures are due to the same mode of formation as those of Germany and the North of England, between which they lie, and of which, in our opinion, they should be considered as forming part.

"A recent fact justifies this assertion. The prolongation of the basin of the Ruhr to the west, now well proved by the Homberg pit, on the left bank of the Rhine. And besides this, the discovery of coal at Crefeld, that is to say, much further west of the Rhine.

"This extension is moreover clearly indicated by the general strike of the *encasing primary rocks*.

"On looking into the matter carefully, it is easy to see, that in its westernmost part the German basin bends slightly to the south, and from what we have said above it is also easy to perceive that the basins of Stalberg and the Worm merely form the southern ridge of the great basin." . . . . .

"According to this view, the Coal-measure zone in question would extend nearly continuously from Eastern Westphalia, or from the sources of the Lippe near Paderborn, to Scotland, about 250 leagues. Compared to other neighbouring geological formations, and even to other Coal-bearing deposits, this great extension is not astonishing, since the great Carboniferous horizon of North America is worked over a distance of more than 350 leagues from E. to W.! In other words, this deposit is within reach over nearly that entire distance. With us, or in Europe, the points which are rich and easily worked, such as everything seems to show that the Dutch Limburger one will be, have hitherto been few and rather limited in extent. This is no doubt why their connexion, or the continuity of the great deposit, had never until now been clearly recognized. We may add that if the northern extension of the Belgian basin has not been inquired into before, it is because the question is of purely scientific interest, the value and extent of that part of it which was already known having easily satisfied the demand hitherto." . . . . .

[Here follow particulars as to previous trials for coal in Dutch Limburg.]

"Four borings, Nos. 1, 2, 3, and 4, have been put down at considerable distances apart, and in each case the Coal-measures with coal have been proved." . . . . .

[The accounts of these borings are then given in detail. From them the dip of the Coal-measures is inferred to be 1·16 in 100 to the North. Then comes an estimate of the area of the new Coal-field, which, according to the author, is at least 10 kilometres in breadth. In a letter to Prof. Prestwich, F.R.S., Prof. Lambert adds the following paragraph.]

"To the reasons which I have given in favour of the northern extension of the Coal-fields of Germany, France, Belgium, and England, and of their continuity, it may be added that north of the Ruhr basin at Osnabruck and at Ibbenburn (north of the Permian), well-characterized Millstone-grit occurs with seams of coal—or, better, of anthracite, dipping to the South.

"Lastly, is it reasonable to suppose that the Coal-measures running from Paderborn eastward to the Channel, and probably as far as Scotland to the West, has not a breadth proportional to its length, as is the case with all the Carboniferous formations?"

REPORTS AND PROCEEDINGS.

Geological Society of London.—I.—June 7th, 1876. Prof. P. Martin Duncan, M.B., F.R.S., President, in the Chair.—The following communications were read:—

1. "On British Fossil Cretaceous Birds." By Harry Govier

Seeley, Esq., F.L.S., F.G.S., Professor of Physical Geography in Bedford College, London.

In this paper the author gave an account of the remains of birds which have been collected from the Cambridge Upper Greensand. Of the head, the only portion yet recognized is that part of the brain-case behind the parieto-frontal suture. It indicates a skull as large as that of the red-throated Diver, which it resembles in details of structure. The vertebral column is represented by lower cervical vertebræ, which have the centrum small and compressed from side to side. The dorsal vertebræ are small, rounded on the under side as in the Gannet, and often have the articular ends biconcave, or have a concavity in the centre of the saddle. There were transverse processes as in modern birds, and the ribs had a similar double articulation. The sacrum was unusually large, and included many vertebræ. Its anterior end resembles that of a Gull's sacrum, in being flattened or concave. The vertebræ are rounded anteriorly, and distinguishable from each other; but posteriorly they are blended, and resemble the postarticular part of the sacrum of the Diver. Some small vertebræ were thought to be caudal, and considered to be probably elements of the ploughshare, or *os coccigis*.

No trace of any bone of the anterior limb has been detected; while of the hinder limb, the femur, tibia, fibula, and tarso-metatarsus are all known. The femur and tarso-metatarsus are the bones most like those of the Diver. The fibula is unusually large. The tibia has a moderate patelloid process, and shows resemblances to several water birds. The bones are so fragmentary that the size of the animal can only be given roughly as similar to that of the Diver, but with a shorter neck. The affinities of the animal are strongest with *Colymbus*. It also closely resembles Prof. Marsh's Cretaceous genus *Hesperornis*, and like that genus may be supposed to have had teeth. The species were described as *Enaliornis Barretti* and *E. Sedgwicki*. Some bones were also described thought to indicate birds in which the extremities of the bones remained unossified throughout life.

2. "On two Chimæroid Jaws from the Lower Greensand of New Zealand." By E. T. Newton, Esq., F.G.S., of H. M. Geological Survey.

The two jaws which were the subject of this communication form part of the collection of fossils from the Lower Greensand of New Zealand deposited in the British Museum by Dr. Hector. One of the specimens, a right mandible, was referred by the author to *Ischyodus brevirostris*, Ag., a species from the Gault of Folkestone, hitherto known only by name, no description or figure of it having been as yet published. Through the kindness of the Earl of Enniskillen, the original type-specimen of this species was exhibited to the Society. The author then described a perfect mandible from the Cambridge phosphatic deposits, and stated that the examination of a large series of specimens showed a considerable variation in the form of the teeth in different individuals. The New Zealand mandible was then compared with these British specimens, and was said to differ less from some of them than they did among themselves.

The second specimen, a small right maxilla, possessing but one tooth, and this of a peculiar form, was compared with the corresponding bone in *Ischyodus*, *Edaphodon*, *Elasmodus*, *Ganodus*, *Chimæra*, and *Callorhynchus*. The form of the tooth appeared to agree better with that of the last-named genus than with any of the others; but reasons were given for believing that it differed generically from this, and from all other known forms of Chimæroid jaws; and the author therefore proposes to call it, in allusion to the form of the tooth, *Upsilodus Hectori*.

3. "On a Bone-bed in the Lower Coal-measures, with an Enumeration of the Fish-remains of which it is principally composed." By J. W. Davis, Esq., F.L.S., F.G.S.

In this paper the author described a thin bed composed chiefly of remains of fishes, which rests immediately upon the "Better-bed Coal" of the Lower Coal-measures in Yorkshire. The bed varies from a quarter to five-eighths of an inch in thickness, and is overlain by a thick bed of blue argillaceous shale, containing remains of plants. The author described the order of the deposits both above and below the "Bone-bed," and gave a list of the organisms of which remains are found in the latter, including species of *Gyracanthus*, *Ctenacanthus*, *Lepracanthus*, *Acanthodes*, *Pleuracanthus*, *Orthacanthus*, *Diplodus*, *Pleurodus*, *Helodus*, *Cladodus*. *Pæcilodus*, *Petalodus*, *Harpacodus*, *Ctenoptychius*, *Megalichthys*, *Holoptychius*, *Strepsodus*, *Acrolepis*, *Platysomus*, *Acanthodopsis*, *Amphicentrum*, *Rhizodopsis*, *Cycloptychius*, *Gyrolepis*, *Palæoniscus*, *Cælacanthus*, and *Ctenodus*. The author also described spines which he regarded as indicating two new genera of Elasmobranchs, one probably allied to *Pleuracanthus*, and the other (*Hoplonchus*) allied to *Onchus* and *Homacanthus*. Bones belonging to the Labyrinthodont genus *Loxomma* are met with rarely in the deposit.

4. "Note on a Species of Foraminifera from the Carboniferous Formation of Sumatra." By M. Jules Huguenin. Communicated by Prof. Ramsay, F.R.S., V.P.G.S.

The author described some globular Foraminifera, belonging or allied to *Fusulina*, from a Carboniferous deposit containing *Producti* and *Phillipsiæ*, which occurs N.E. of Padang and S. of the lake of Singkarak in Sumatra. The author described the structure of these fossils, which he compared with *Fusulina cylindrica* and *F. depressa*, and arrived at the conclusion that they belong to a new genus, to which perhaps the North American *Fusulina robusta* also belongs.

5. "On the Triassic Rocks of Somerset and Devon." By W. A. E. Ussher, Esq., F.G.S.

The author stated that the Trias of Devon and Somerset was divisible into three groups, occupying distinct areas.

The first lies north of the Mendip Hills, where the Trias is thinnest and assumes its simplest character, consisting of marls and Dolomitic conglomerate, the former predominating, the latter not only occurring as a basement series, but in some cases persisting continuously upwards as the marginal equivalent of the marl, as Rhætic beds overlie both alike. South of the Mendips the Trias is similarly constituted, but is of much greater thickness.

The second area embraces the country south of the Polden Hills as far as a north and south line through Taunton.

The chief portion of the Trias in this area, as in the northern, consists of marls; but unless the breccias of Wembdon, near Bridgewater, are portions of a basement series, faulted up, but elsewhere concealed, the lower division consists of sandstones found resting on the flanks of the Quantocks, flanking outliers of the older rocks, and here and there faulted up.

In the lower parts of the marls in the Vale of Taunton and other places occasional beds of sandstone are found, which from their position may be regarded as equivalent to the Upper Keuper Sandstone of Professor Hull. The sandstones of this area differ from the conglomerates of the Mendip country in occupying a definite subordinate horizon to the marls, and not dovetailing into them.

The third area, bounded on the north by the Bristol Channel, on the south by the English Channel, on the east by the Blackdown range, and on the west by the Culm and Devonian highlands, presents the most complex relations of the Trias in the south-western counties.

The upper member of the series, as in the other districts, consists of marls; they contain occasionally thin beds of sandstone towards the base, which may be considered, although apparently of local occurrence, as Upper Keuper Sandstone. They are underlain by sandstones. In these two upper divisions we have the continuation of the whole Triassic series of the second area; and in the third underlying division conglomerate and pebble-beds. From Watchet to a point west of Wellington this division is represented by hard-bedded conglomerate, thence to the south coast by sands with rounded grains and pebbles, at first of quartz grit and slate, gradually giving place to the large foreign-derived quartzites of Budleigh Salterton.

A second series of marls is found to underlie the conglomerate and pebble-beds conformably. This attains as much as 500 feet in thickness near the south coast, but in the northern part of the district does not appear to exceed 200 feet.

The base of the series is composed of sandstone, breccia, and occasionally clays, occurring at different horizons in different parts of the area, and each variety locally predominant over the others.

The clay beds appear to be confined to the neighbourhoods of Exeter and Crediton. The upper part of the division south of Bradninch seems to consist of red sandstones, the lowermost and principal part of the division consisting of breccia. North of Bradninch the sandstone occupies the principal portion of the division, sometimes apparently to the exclusion of the breccia. Towards Wiveliscombe the upper part of the series for from 15 to 30 feet consists of breccia and breccia-conglomerate, the major part con-coast-line of the lake is proceeding at the rate of from 30 to 40 feet in twenty years.

Fringing the basin of Lake Ontario are terraced highlands of loose gravel, with here and there apparent stratification of a partial character, called Artemisia-gravel by the Canadian Survey. A peculiar feature of these gravel ridges is the presence in them of numerous small lakes. The author records the bursting of the natural dam of one of these lakes, and mentions the occurrence of a peculiar hollow, probably the basin of a lake that burst in a similar way in former times.

Freshwater shell-deposits occur here and there; further down the river a brackish-water shell is found in them; and they are replaced lower down by marine deposits. The author quotes various opinions relative to the formation of these terraces and shell-deposits by supposing the former existence of a barrier of ice or rock lower down the river, and concludes that by these phenomena noteworthy alterations are year by year being made on the surface of the land.

4. "The Glacial Climate and the Polar Ice-cap." By Joseph John Murphy, Esq., F.G.S.

The author agrees with Mr. Croll in thinking that a glacial epoch must be one of maximum excentricity of the earth's orbit, and that the northern and southern hemispheres during such an epoch must be glaciated alternately; but he maintains, in opposition to that writer, that the glaciated hemisphere must have its *summer* in aphelion. He intends this paper to be a reply to Mr. Croll's objections to this theory as put forth in his work on "Climate and Time." The author holds that some of Mr. Croll's conclusions are erroneous, and concludes with some remarks on Mr. Tylor's paper read before the Society in April, 1875.

5. "On the Discovery of Plants in the Lower Old Red Sandstone of the Neighbourhood of Callander." By R. L. Jack, Esq., F.G.S., and R. Etheridge, Jun., Esq., F.G.S., of the Geological Survey of Scotland.

The authors give an abstract of the various previous references to the existence of remains of land-plants in deposits of Old Red Sandstone age, and mention the following localities in Scotland in which such remains have recently been discovered by them:—1. Buchanan Castle Quarry, near Drymen; 2. Old Quarry at small reservoir at Kilmahew; 3. Green Burn, Keltie Water; 4. Keltie Water, above Chapelrock; 5. Keltie Water, below Brackland Linns; 6. Quarry at Kames Farm, near Callander; 7. Quarry at Easterhill, near Gartmore; 8. Quarry in Cameron plantation, near Alexandria; 9. Turnpike road at Overballoch, Loch Lomond;—and the localities from which the specimens noticed in this paper were obtained, namely, a quarry 2½ miles from Braendam House, and the south-west corner of Muir plantation, near Callander. The plant-remains are described as being of a very fragmentary nature, and as occurring in the two last-named localities in a deposit consisting of greenish-grey flags and thin-bedded sandstones about 500 feet in thickness, the best specimens being in the sandstone. They present the appearance of elongated flattened stems, about one inch wide on the average, sometimes represented only by casts, sometimes by black carbonaceous films. They are ornamented with a series of pucker-like depressions when seen from the interior, or with a number of wart-like eminences when viewed externally. The latter are the scars of the points of issue of the vascular bundles passing to the leaves. Along the margins are seen spines or thorn-like projections, which may be the leaves or their bases; these are apparently arranged in spiral rows. Some stems appear to show dichotomous branching. The authors discuss the relationships of these remains with other described Devonian forms, and regard them as most nearly allied to *Psilophyton princeps*, Dawson. They describe the plant with doubt as a species of *Psilophyton*.

6. "On an adherent Form of *Productus* and a small *Spiriferina* from the Lower Carboniferous Limestone Group of the East of Scotland." By R. Etheridge, Jun., Esq., F.G.S., of the Geological Survey of Scotland.

The author commenced by summarizing the different views that have been expressed by writers as to the mode of life of the *Producti*, and the function to be ascribed to the spines with which their shells are furnished, in order to show the uncertainty that prevails upon these points. He then described specimens of a small *Productus*, found attached to encrinite stems and fragments of Polyzoa, in the shale over the No. 2 Limestone of the Lower Carboniferous Limestone group, chiefly in the neighbourhood of Dunbar. The shells are attached by having some of the spines of the ventral valve wound tightly round the bodies to which they adhere, sometimes singly, sometimes in clusters, the number of spines implicated in the adhesion varying from two to seven or more. The attachment took place during the life of the Crinoid, as evinced by the subsequent growth of the latter, leading in many cases to the more or less complete imbedding of the *Productus*. From the consideration of the characters presented by the more mature valves, the author stated that the nearest affinity of this species of *Productus* appears to be with *P. Wrightii*, Dav., but that it shows peculiarities allying it to *P. longispinus*, Sow., *P. scabriculus*, Mart., and *P. undatus*, Defr. He was not prepared to describe it as a distinct species, but suggested for it the name of *Productus complectens*, in allusion to its embracing habit, in case of its proving to be distinct.

The *Spiriferina* described by the author was compared by him with *S. cristata*, Schl., var. *octoplicata*, Sow., and with *S. insculpta*, Phill., from both of which it differs in certain characters; but as only one specimen has been met with, he refrained from founding a new species upon it. The specimen is from Fullarton Quarry, near Temple, Edinburghshire.

7. "Notice of the Occurrence of Remains of a British Fossil *Zeuglodon* (*Z. Wanklyni*, Seeley) in the Barton Clay of the Hampshire Coast." By Harry Govier Seeley, Esq., F.L.S., F.G.S., Professor of Physical Geography in the Bedford College, London.

In this paper the author described the remains of a species of

Zeuglodon obtained by the late Dr. A. Wanklyn from the Barton Cliff, consisting of a great part of the skull, about the same size as that of *Zeuglodon brachyspondylus*, Müller. The bones preserved are the maxillary, frontal, and parietal bones. The left maxillary shows the remains of five teeth in a length of rather less than seven inches, the first two of which had simple conical crowns and a single fang; the sockets of these are elliptical. The third tooth is considerably compressed, with a sharp margin, which has four small denticles on each side of the large median denticle. The following teeth exhibit somewhat similar characters, and each possesses two fangs. A single tooth, resembling the canine of a Carnivore, was found with the specimen, and was probably one of those missing from the first sockets. The characters of the bones of the head were described in more or less detail; the frontal region is flattened, with a sharp crest continued along the parietal region, as in *Z. brachyspondylus*; but the crest is not flattened posteriorly into a narrow table, as in that species, nor is the parietal united with the frontal by a folded suture. The species, named *Z. Wanklyni* in memory of its discoverer, differs from all known species of the genus in the shortness of the inter-spaces between the teeth.

8. "On the Remains of *Emys Hordwellensis*, from the Lower Hordwell Beds in the Hordwell Cliff, contained in the Woodwardian Museum of the University of Cambridge." By Harry Govier Seeley, Esq., F.L.S., F.G.S., etc.

The remains described by the author consist of some fragments constituting the greater part of the plastron and carapace of a species of *Emys* obtained from a bed in Hordwell Cliff about 20 feet below that which yields the chief remains of *Crocodilus Hastingsiæ*, and about 10 feet above the brackish-water Upper Bagshot beds. The preserved portion of the carapace is 9 inches long; when perfect it was probably about 12 inches long and 10 inches broad. Its distinctive characters were said to be the broad, short gular scute, with sinuous sutures; the subtriangular nuchal scute; the subpentagonal first vertebral scute, broader than the succeeding quadrate vertebral scutes; and the concentric ornamentation left on the carapace and plastron by all the scutes. The author proposed for the species the name of *Emys Hordwellensis*.

9. "On an associated series of Cervical and Dorsal Vertebræ of *Polyptychodon* from the Cambridge Upper Greensand, in the Woodwardian Museum of the University of Cambridge." By Harry Govier Seeley, Esq., F.L.S., F.G.S., etc.

The author remarked upon the rarity of vertebræ of *Polyptychodon* in the Cambridge Greensand in comparison with the abundance of teeth, and stated that those collected do not appear to be the remains of more than two individuals, probably representing two species. One series from Haslingfield was described and figured by Prof. Owen in 1860; the other, somewhat smaller series, described in the present paper, is from the Huntingdon Road. The author described in detail the structure of the atlas and axis and of the five succeeding (cervical) vertebræ; nine dorsal vertebræ were also described.

10. "On *Crocodilus icenicus*, Seeley, a second and larger Species of Crocodile from the Cambridge Upper Greensand, contained in the Woodwardian Museum of the University of Cambridge." By Harry Govier Seeley, Esq., F.L.S., F.G.S., etc.

In this paper the author described a cervical and a dorsal vertebra of a new species of Crocodile. The former is probably the last cervical. It is 2¼ inches long, and differs from that of existing Crocodiles in the large size of the parapophyses, the distinct anterior notch in the neural arch for the vertebral nerve, and the perfect convexity of the articular ball. The dorsal vertebra is the sixth or seventh; it measures 2½ inches in length, and shows a depression and perfect convexity of the articular ball, which distinguish it from existing species. The animal was probably about 16 ft. long.

11. "On *Macrurosaurus semnus*, Seeley, a Long-tailed Animal with Procœlous Vertebræ, from the Cambridge Upper Greensand, preserved in the Woodwardian Museum of the University of Cambridge." By Harry Govier Seeley, Esq., F.L.S., F.G.S., etc.

The author described a series of about 40 associated and nearly successive caudal vertebræ obtained from one of the deeper phosphatite workings on Coldham Common. The tail, when complete, probably included 50 vertebræ, and measured 15 feet in length. The articulations of the earlier vertebræ are procœlous, then they become nearly flat, then biconcave, and towards the end of the tail irregular. There are no chevron bones. The neural arch in the earlier part of the tail was supported on pedicles rising from the centrum, depressed and devoid of neural spine. The neural arches were of great antero-posterior extent and compressed. The author remarked that although the tail as a whole is more in accordance with the Lacertian type than with any other order of true reptiles, the combination of the procœlous character with the absence of chevron bones is unknown to him elsewhere. He added that the metapodium described and figured by him in 1871, under the name of *Acanthopholis platypus*, may perhaps belong to the foot of *Macrurosaurus*, in which case the latter would probably indicate a modification of the Crocodilian type, and the individual to which the tail belonged would have been about 30 feet long.

12. "On the Mechanism of Production of Volcanic Dykes and on those of Monte Somma." By R. Mallet, Esq., F.R.S., F.G.S.

The author stated that in 1864 he made a careful trigonometrical survey of the escarpment of Monte Somma, especially with reference to the numerous dykes by which the rocks composing it are intersected. He described in detail the phenomena of direction of the dykes, especially as regards the axis of the cone of Vesuvius; to this direction he gives the name of *orientation*. Of twenty-seven dykes ten presented an approximately vertical line, whilst all the rest had a sensible dip or "hade." The dykes are in no cases intersected by coherent beds of lava, but in one instance the top of a dyke was stopped by such a bed. Many of the dykes bifurcated or branched, and frequently two dykes intersected each other at considerable angles. These and other circumstances prove that the dykes were produced at different and successive ages. Many of them were fractured and displaced in consequence of movements of the mass of rock traversed by them; and these dislocations are regarded by the author as indicating the vast extent and force of the internal movements, due principally to gravity, which are constantly taking place in the mass of volcanic cones. These movements greatly influence the position of the dykes, and render it difficult to ascertain that which they originally occupied. The dykes thin out at various heights, and their superior and northern terminations were found not to reach the existing surface, notwithstanding the amount of denudation that has taken place; and hence the author concludes that they never reached the surface of Somma, when it was the wall of an active volcano. The author further indicated a process by which beds or plates of lava descending the slopes of a volcano may change their direction, and becoming imbedded in the detritus accompanying or following them, may, to a greater or less extent, simulate dykes, although in this case the two sides of the plate will present the differences always seen in the upper and under surfaces of a bed of lava. The orientation-lines of five or six of the observed dykes were said to pass approximately through the axis of the cone of Vesuvius, but all the rest presented great diversities, and some, when prolonged, would not touch the cone at all. In making a lithological examination of the dykes of Somma, the author directed particular attention to the position of the elongated air-bubbles found in the material of each dyke, considering that the direction of the longest axis of these bubbles would indicate the flow of the material when in fusion. He stated that on the whole the long axes of the bubbles are nearly horizontal or pointing at moderate angles upwards in directions very nearly parallel to the plane of the dykes at the place where they occur. Hence he inferred that the dykes were filled by injection not from below but nearly horizontally. The author further referred to the mineralogical characters of the materials of the dykes, and stated that they are not all composed of leucitic lava; he also mentioned the occurrence of cross columnar structure in some of the larger ones. After referring to the differences observable in the physical condition of the two surfaces of some dykes, the author proceeded to consider the mode of the fissures which, when filled, constitute volcanic dykes. He maintained that the production of a fissure and its filling with molten matter must have been simultaneous and due to the same cause, namely, the hydrostatic pressure of the liquid lava more or less filling the crater, the pressure originating the fissure into which the pressing liquid at the same time enters; a fissure thus produced and filled will always be widest near the crater, so that, if the material of the cone were perfectly uniform, the dykes produced would be wedge-shaped. But from the absence of this uniformity and other causes, fissures commenced at the interior and propagated into the mass of volcanic cones can rarely be uniformly distributed round the crater or produced in regular vertical planes in a truly radial direction. Hence the author concluded that it is unsafe to attempt to fix the position of an ancient crater by means of the intersection or concurrence of the lines of apparent "orientation" of dykes alone. The author stated that the intrusion of volcanic dykes cannot so greatly influence the slope of volcanic mountains as has been supposed.

13. "On the Metamorphic Rocks surrounding the Land's End Mass of Granite." By S. Allport, Esq., F.G.S.

In this paper the author described the results of a microscopic examination of certain metamorphic rocks surrounding the Land's End granite, indicating the changes produced by the intrusion of the latter upon clay-slate and upon certain igneous rocks. The slates in contact with granite become converted into tourmaline- and mica-schists, and are found to contain crystalline quartz, tourmaline, and three distinct varieties of mica, with occasionally tremolite, magnetite (and andalusite ?), and in some localities felspar. Their structure is also changed, the most remarkable changes being foliation with every gradation from nearly straight parallel lines to the most complicated contortions, and concretionary structure by segregation of quartz and mica, the result being a spotted schist. The strata near the granite contain far more quartz than those at a distance; and the author thought that there could be no doubt that much of the quartz has been derived directly from the intruded rock. He referred particularly to the fluid-cavities contained in the quartz of the granite, schorl-rock and altered slates; and from his observations upon them, stated that he was compelled to dissent from the views of Mr. Sorby, inasmuch as he found no uniformity to prevail in the relative sizes of the bubbles and fluid-cavities in the quartz crystals belonging to precisely the same portion of rock, or even in the same crystals. Hence he regarded it as impossible to arrive at even an approximate estimate of either the temperature or the pressure under which a given rock was formed from a consideration of such characters. The author next described the characters and mode of occurrence of tourmaline both in the granite and in the schorl-rock, and inferred that at the separation of the latter from the former the whole mass was in a plastic state, and that then the tourmaline and quartz became crystallized in an order varying in accordance with varying conditions. He also noticed the alteration of tourmaline producing pseudomorphs of that mineral; and stated that while all the three varieties of mica found distinctly furnish the red lithium-line when treated spectroscopically, this is most strongly marked and persistent in the white variety, which is probably a typical lepidolite.

The altered dolerites and basalts described by the author in the remainder of his paper are marked as "Greenstones" on the map of the Geological Survey. They were stated to vary in colour from dark bluish green to dark brownish green, and in texture from coarsely crystalline rocks, not fissile in any direction, to fine-grained or compact rocks with an imperfect slaty cleavage. The coarsely crystalline rocks are regarded by the author as altered dolerites, and some, if not all, of the more compact varieties, as originating from fine-grained basaltic portions of the same rocks. The author was unable to decide whether these masses are contemporaneous and interbedded or intrusive sheets,—both may be present; but in any case they are older than the granite. He described in some detail the structure of specimens of these altered rocks from many localities, the microscopic examination of which shows that the pyroxenic mineral, whether augite or diallage, has frequently been converted into a hornblendic substance, and that actinolite is found filling cavities and fissures in precisely the same manner as other products of alteration. The imperfect cleavage of the more compact varieties is regarded by the author as in accordance with the facts observed in typical slates. The metamorphism of the dolerites is regarded by him as different in kind from that of the slates, and caused rather by a decomposition and rearrangement of mineral substances *in situ* than by an introduction of new material; in many cases the process of alteration may be followed step by step; and from the evidence it would appear that two rocks of similar origin and composition may follow two different lines of metamorphosis, and thus become converted into two totally different substances; and again many of the metamorphic rocks have undergone a second series of changes, brought about chiefly by chemical forces, and indicated by the occurrence of micaceous and chloritic pseudomorphs after tourmaline and an alteration (hydration) of the mica.

With regard to the origin of the granite of Cornwall, the author said that neither observation in the field nor microscopical study lends any support to the notion that it is a metamorphic rock; but, on the contrary, that there is the clearest evidence of former deep-seated volcanic action in the disturbance and alteration described in his paper, and in the enormous number of granitic and felsitic dykes intersecting the country for miles. The mode of occurrence of granite in other localities also seems to him to furnish evidence in the same direction.

14. "On the Relation of the Upper Carboniferous Strata of Shropshire and Denbighshire to Beds usually described as Permian." By D. C. Davies, Esq., F.G.S.

The author described sections obtained at the Ifton Rhyn Collieries and other places in the neighbourhood, and compared these with other sections displayed in different parts of England and the continent, and also in Nova Scotia, and stated his conviction that from the *Spirorbis*-limestone upwards to and including the Permian we have one continuous series of deposits. He maintained that there is no real general break in the sequence of the strata or in the continuity of life, but only local unconformabilities marked by equally local gaps in the succession of life.

15. "Notes on the Physical Geography and Geology of North Gippsland, Victoria." By A. W. Howitt, Esq., F.G.S.

The earliest formation of which any trace is left in this district is the Silurian; all traces of any older rocks being removed, probably by the same agencies which have contorted and metamorphosed the Silurian slates and sandstones. The surface of all these Silurian strata show signs of great denudation previous to the deposition of the Devonian. The period that elapsed between these two epochs was one of volcanic activity, apparently subaerial and terrestrial, and representing the Lower Devonian. The Middle Devonian strata consist of shales and sandstones devoid of any traces of volcanic action, which, however, again becomes apparent in the Upper Devonian. The latter consists of conglomerates, sandstones, and shales, interstratified with aqueous deposits. The prevailing red colour of these beds the author suggests may possibly indicate lacustrine rather than marine conditions.

The next in the series of deposits present in North Gippsland are of Tertiary age, and rest horizontally on the flanks of the mountains at elevations nowhere exceeding 1000 feet. At the close of the Miocene and at the commencement of the Pliocene periods the land probably was from 300 feet to 400 feet lower than at present.

The fact that different genera of fish are found in the streams flowing from the north and south sides of the Australian Alps indicates the high antiquity of that watershed. These mountains have been formed by the gradual elevation of the land *en masse,* and its equally gradual erosion by the streams and rivers.

16. "Further Notes on the Diamond Fields, etc., of South Africa." By E. J. Dunn, Esq. Communicated by Prof. A. C. Ramsay, F.R.S.

These notes are intended to serve as additions and corrections to the author's paper read in 1873.

Further mining operations at De Beer's show that the "pipes" are more recent than the sheet of dolerite and other intrusive rocks surrounding them. At this mine the only instance of a dyke traversing the "pipe" occurs. Though the rock composing it was too much decomposed to be determined, it was still quite distinct. As the mines are worked out, they disclose a form less circular than at first supposed.

The first effect of the disruptive force was to cause a rent in the rocks, the sides of which were afterwards torn away in the weaker parts by the intrusive rock until the present form resulted.

The "cores or pipes" have decomposed downwards, being darker coloured and less decomposed at 80 or 100 feet from the surface and towards the centres. Several small freshwater shells were discovered in Kimberley Mine, in an apparently undisturbed deposit.

Gold is mined for at Leydenburg and Eersteling, in the Transvaal Republic. The rocks in which it occurs are generally barren-looking, and vary very much in strike. The alluvial gold at Leydenburgh as doubtless been supplied from two distinct sources; it is coarse and nuggetty as a rule, well rounded, and generally coated with oxide of iron. Lumps up to 10 lbs. weight have been found; it is of good quality, worth from 76 fr. to 80 fr. per oz. The auriferous rocks at Eersteling are steatitic and chloritic schist resting on gneiss, and overlain by rocks which at Leydenburg are auriferous.

Cobalt is found near Oliphant River, in fine-grained felsite rocks. It does not occur in lodes, but in small threads and lenticular veins, running parallel to a dyke of fine-grained dolerite. The widest vein of ore was eight inches thick. More than 100 tons of ore have been sent to London.

(To be concluded in our next Number.)

CORRESPONDENCE.

NOTES ON THE GEOLOGY OF NEW GUINEA.

SIR,—From the interest which has of late been taken by the public in matters relating to New Guinea, the following geological notes may be of interest.

I have been favoured by my friend, Mr. C. S. Wilkinson, Govt. Geologist, N. S. Wales, with a newspaper slip containing an abstract of a paper by himself, read before the Linnæan Society, Sydney, 28th February, 1876, *Notes on a Collection of Geological Specimens collected by W. Macleay, Esq., from the Coasts of New Guinea, Cape York, and Neighbouring Islands*, from which I take the following. The specimens upon which Mr. Wilkinson lays the greatest stress are Oolitic Tertiary Limestone from Bramble Bay, yellow calcareous Tertiary clay from Katan River, and yellow and blue ditto from Yale Island and Hall's Sound. These clays, from the evidence afforded by the contained fossils, Mr. Wilkinson considers to be Lower Miocene, and, he says, are exactly similar in lithological character to the Lower Miocene beds near Geelong and Cape Otway, Victoria. The clay from Hall's Sound contained at least two Victorian species, *Voluta macroptera*, M'Coy, and *V. anto-cingulata*, M'Coy, with species of *Ostrea*, *Cytheræa*, *Crassatella ?*, *Pecten*, *Turritella*, *Natica*, *Triton ?*, *Dolium ?*, *Astarte*, *Corbula*, *Læda*, *Venus*, *Cypræa*, and two Echinoderms. The calcareous clay from Katan River, west side of the Gulf of Papua, contained only a few broken shells; but both it, and the Oolitic Limestone of Bramble Bay, Mr. Wilkinson believes to be of the same Miocene formation. This is very interesting from the fact, that hitherto no Miocene Tertiary beds have been met with in the East of Australia farther north than the boundary between Victoria and N. S. Wales—although they are highly developed in the former and S. Australia, extending westwards towards W. Australia. According to Macleay and Signor D'Alberti, Yale Island is formed of a calcareous sedimentary rock, dipping inland and composed of Corals, Shells, and Echini. In the valleys trap is found, and the higher portions of the hills, which attain a height of 700 to 800 feet, are composed of Coralline Limestone. Mr. Wilkinson considers that the occurrence of these beds, which he believes to be Miocene, in New Guinea, suggests the former land-connexion of the latter with Australia, the shallowness of the intervening Torres Straits lending additional weight to this view. Tertiary rocks described by Mr. Macleay as existing at Cape York, especially a ferruginous sandstone overlying the porphyritic granite of that locality, may be perhaps correlated with these New Guinea beds.

EDINBURGH. R. ETHERIDGE, JUN.

APPARENT AND TRUE DIP.

SIR,—In reference to the subject of Apparent and True Dip, attention might be redirected to Mr. Dalton's "Geological Problems," published in the GEOLOGICAL MAGAZINE, Vol. X. p. 332.

H. B. W.

NEW AND EXTENSIVE SECTIONS OF BOULDER-CLAY AT LIVERPOOL.

SIR,—That your readers, during the tourist season, may have an opportunity of seeing a series of the largest and most important sections they may ever meet with in their lives, I lose no time in directing their attention to the excavations for the new Canada Docks, near Bootle Station, Liverpool. There is a lower glacial clay (which is worked with the pick) underlying a greater or less thickness of non-glacial gravel and sand; but the great deposit exposed is the upper or brick clay (which is worked with the spade). Though I had previously seen boulders in this clay in different localities, I was not prepared to find such an array of large blocks more or less imbedded in the clay at different levels, and apparently in the spots where they had been dropped. The majority, so far as my observations extended, were greenstone, and numbers of them might be seen lying near to each other as if they had been picked up from the same spot (in the Lake District) by a mass of coast-ice, which floated them and laid them down without severing their family connexion. Many of the boulders were quite five feet in length, and in shape varied from round to sub-angular and angular. Most of them were intensely glaciated. I have to thank Mr. Morton, F.G.S., for directing my attention to the above sections.

D. MACKINTOSH.

LLANDOVERY ROCKS IN THE LAKE DISTRICT.

SIR,—In reply to Mr. Aveline's last letter, I beg to state that the evidence relied on by me in drawing up the Table was obtained from the published statements of the authors whose names appear at the head of the column referred to (p. 156); and who, I believe, have not only obtained "fossil evidence" sufficient to warrant their speaking "confidently of their position," but have been able also to qualify this by "a careful stratigraphical survey of the rocks."

I am permitted also to state that Professors Harkness and Nicholson have recently discovered a group of fossils in these mudstones which, if fossil evidence is to be recognized as of any importance (and he must be a bold man who in the present state of our knowledge is prepared to cast this evidence entirely aside), make it almost impossible for these beds to be so high in the succession as Mr. Aveline would have us believe. Moreover, these fossils are specifically for the most part identical with those of the same genera found in Wales in Upper Bala and Llandovery rocks. The full particulars of this interesting and important discovery will be communicated by Professors Harkness and Nicholson to the British Association at Glasgow; but I am allowed to state here that the result has been to prove "that the sequence from the Coniston Limestones to the mudstones is perfect, and that there is no unconformability, but that the mudstones must be regarded as the highest portion of the Bala series," or as the equivalents of the Lower Llandovery.

Mr. Aveline's own evidence also tells completely against himself when he acknowledges that the mudstones are "the equivalents of the Tarannon shales of Wales, and the Coniston grits and flags equivalent to the Denbighshire grits and flags," since recent evidence is entirely opposed to the view, held by the members of the Geological Survey, and as published in their maps, that the Tarannon shales of Wales overlie the whole of the Llandovery rocks. In a paper which I read at the meeting of the British Association at Bristol last year, I brought forward evidence from numerous sections in North Wales and Shropshire to prove that the pale shales (marked Tarannon Shales on the Survey maps) and some overlying grits in Denbighshire held exactly the same position there stratigraphically as the Llandovery rocks did in South Wales; and the palæontological facts also were in accordance with this view. Since then further researches have been made, and much additional evidence obtained tending to confirm this view. I have no hesitation now in stating, on the strength of palæontological and stratigraphical evidence, that the Tarannon shales are nothing more than equivalents of portions of the Llandovery rocks, chiefly Lower Llandovery, and that the grits associated with and immediately overlying those pale shales in many parts in Denbighshire, and to the east of Corwen, and near Bala, are the equivalents of the Upper Llandovery and May Hill sandstones. Moreover, at these places there is not the slightest sign of an unconformity between the Bala beds and these overlying rocks. I have endeavoured to show in my previous papers that this area, like that of South Wales, probably remained submerged during Mid-Silurian changes, and I have only suggested the probability that areas in Cumberland might also have passed through similar changes without having been at the time raised above sea-level. I may be allowed to state, in defence of the value of palæontological evidence, that it is seldom found to lead one astray to the extent that lithological evidence seems to have done in the case of these Tarannon shales. It seems indeed strange also that a band of shales avowedly with *no fauna* at the time should have a distinctive colouring on the Survey map; when so many truly important series of far greater thickness, and containing numerous rich faunas, should be scarcely recognizable in one tint.

To Mr. Ward I need only say that the general tone of his letter, to say the least of it, is detrimental to the proper discussion of facts; and that the only argument employed by him, that of authority, is one to which I am not at all prepared to bow. My experience hitherto has taught me to rely rather upon the strength of facts than authority, and to value opinions in proportion as they seem to be supported by the facts.

HERIOT HOUSE, HENDON,
August 8*th*, 1876.

HENRY HICKS.

OBITUARY.

C. D'OYLEY H. APLIN.

ꞏ the 9th September, 1875, there died at Somerset, Cape York nsula, N. Queensland, C. D'Oyley H. Aplin, an old and well- wn Australian colonist and geologist. Mr. Aplin emigrated in ꞏ, and carried on pastoral pursuits in the western portion of t is now the Colony of Victoria. In 1849 he proceeded to ieo, where, under his relative, Sir James Brook, he held the ꞏs of Collector of Customs and Surveyor-General. Returning ꞏ a time to England, Mr. Aplin applied himself to scientific ies, especially Geology, and again in 1852 returning to Victoria, 'orked with his brother on the gold-fields. Shortly after this he me a member of Mr. Selwyn's staff on the Victorian Geological 'ey, and remained in this post for many years, assuming the ng Directorate during Mr. Selwyn's absence in England for ve months or more. About the year 1864 Mr. Aplin resigned connexion with the Victorian Civil Service, and set up as nsulting geologist in Melbourne, but again became connected the Geological Survey for a short time, till in 1868 he accepted ivitation from the Queensland Government to act as Govern- t Geologist for the Southern Districts. At the expiry of his of duty he retired into private life, but more recently was inted police magistrate at Somerset, where he died after a very ; illness. By his death the Queensland Government have lost uable officer.

ꞏ a geologist Mr. Aplin was more widely known in the Austra- colonies than in this country. Irrespective of the numerous ꞏ of which Mr. Aplin was the author, or part author, whilst he Geological Survey, the following are amongst his chief ngs:

Report on the Wood's Point Gold-field, Victoria. 1864. Melbourne. Fcap. By Authority.

Report on the Geological and Mining Features of the Gympie Gold-field. 1868. Brisbane. Fcap. By Authority.

Geological Report on the Southern District of Queensland. 1868. *Ibid.*

Geological Report on the Southern District of Queensland, south of the Bunya-Bunya Range, between the River Brisbane and the Coast, including some observations on the Gold Deposits at Jinna and Gooroomjam. 1869. *Id.*

Report on the Geological and Mineralogical Features of a Part of the South and North Portions of the Burnett District. 1870. *Id.*

Report on the Auriferous Country of the Upper Condamine, embracing the diggings at Talgai, Thames Creek, Canal Creek, and Lucky Valley. 1869. Brisbane. Fcap. By Authority.

R. E., JUN.

PROFESSOR ANGELIN, PHIL. DOC.

Born, 1805. Died, 1876.

Nils Peter Angelin, the eminent Swedish Palæontologist, was born in Lund 1805; he studied at the University of his native city, and devoted himself to the pursuit of Natural History, especially to Geology, for the illustration of which he accumulated an immense palæontological collection. He was during many years a private teacher in Natural History.

Under the name "Musæum Palæontologium (suecicum or scandinavicum?)," he published in 1839 a series of fossils from the Silurian and Cretaceous formations of Sweden.

In 1851 he published under the title of "Palæontologia Suecica" the first part of his monograph of the Silurian Crustacea of Scandinavia; the second part, "Palæontologia Scandinavica," appeared in 1854.

He was created a Doctor of Philosophy by the University of Breslau, and was appointed by the University of Lund as Palæontological Docens; soon afterwards he got an ordinary position as Palæontologiæ Adjunctus.

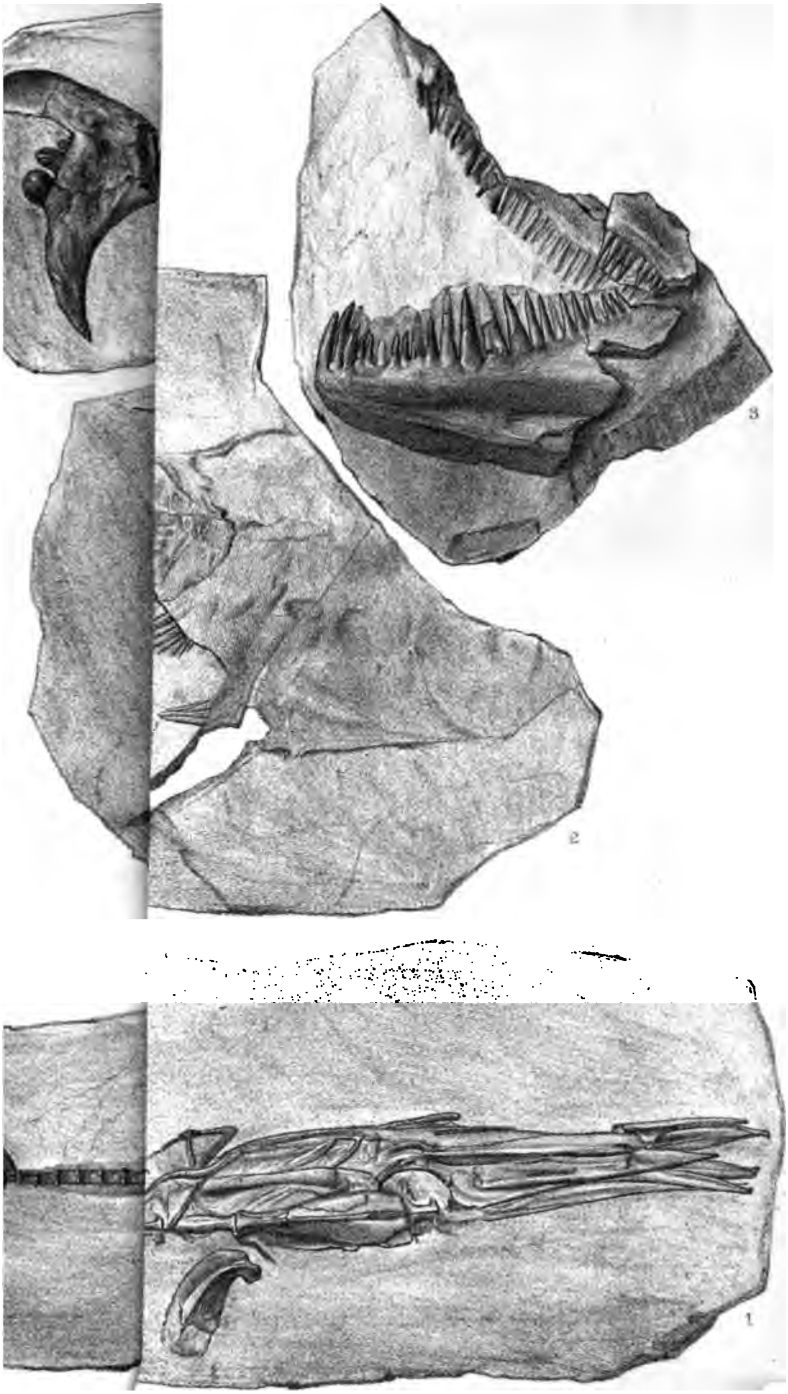
In 1865 his Geological Map of Scania appeared, and in the same year he was created Professor at the Royal Academy of Sciences of Stockholm, and Director ("Intendent") of the Palæontological Department of the States Museum there. His very rich and large collections were bought by the States. He died in Stockholm February 13th, 1876.

We regret to record the death of Mr. Elkanah Billings, F.G.S., for many years Palæontologist to the Geological Survey of Canada, Montreal. We hope to give some account of his life next month.

MISCELLANEOUS.

Royal School of Mines, Jermyn Street.—We understand that the Lords of the Committee of Council of Education have conferred the post of Lecturer on Geology in this Institution (recently vacated by Prof. Ramsay's resignation) upon J. W. Judd, Esq., F.G.S., for some years connected with the Geological Survey of England, and whose name is well known among the leading contributors to the pages of this Magazine.—Edit. Geol. Mag.

Geology of England and Wales.—We understand that Messrs. Longmans and Co. will publish in October next a work entitled "The Geology of England and Wales; being a concise account of the lithological characters, leading fossils, and economic products of the rocks; with notes on the physical features of the country." By Horace B. Woodward, F.G.S. (son of the late Dr. S. P. Woodward, F.G.S., of the British Museum), of the Geological Survey of England and Wales. The book will be illustrated by a chromo-lithographic map and numerous woodcuts.



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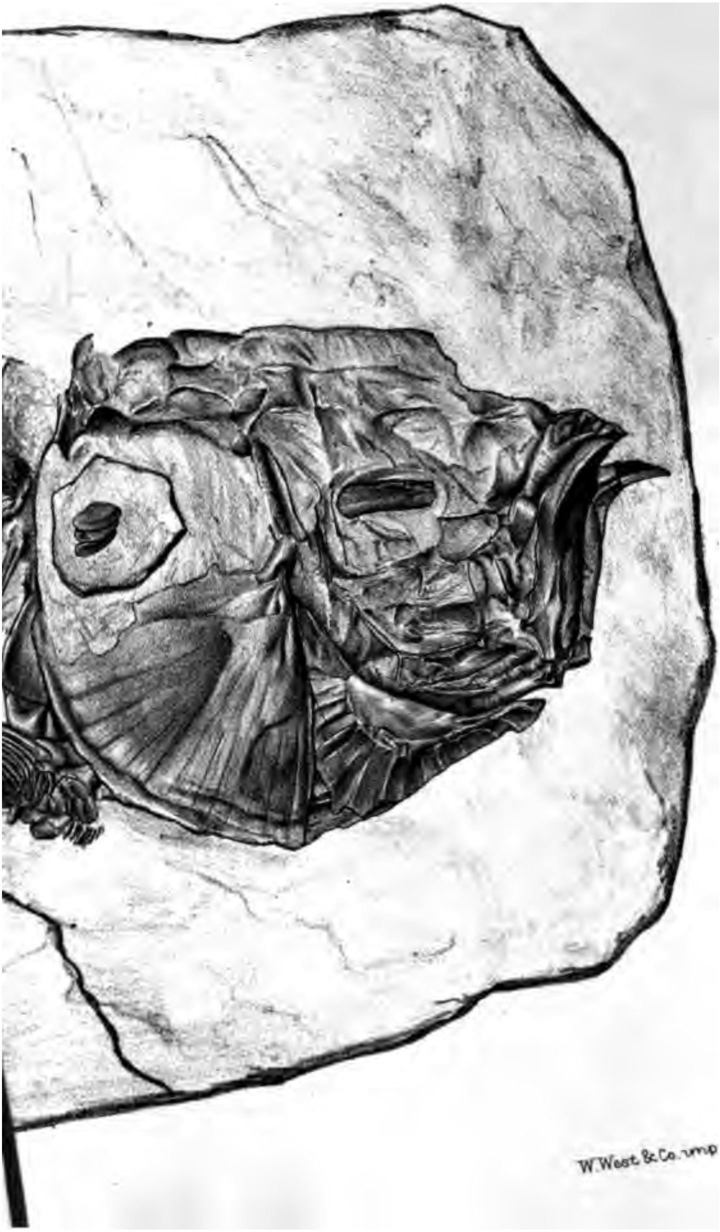

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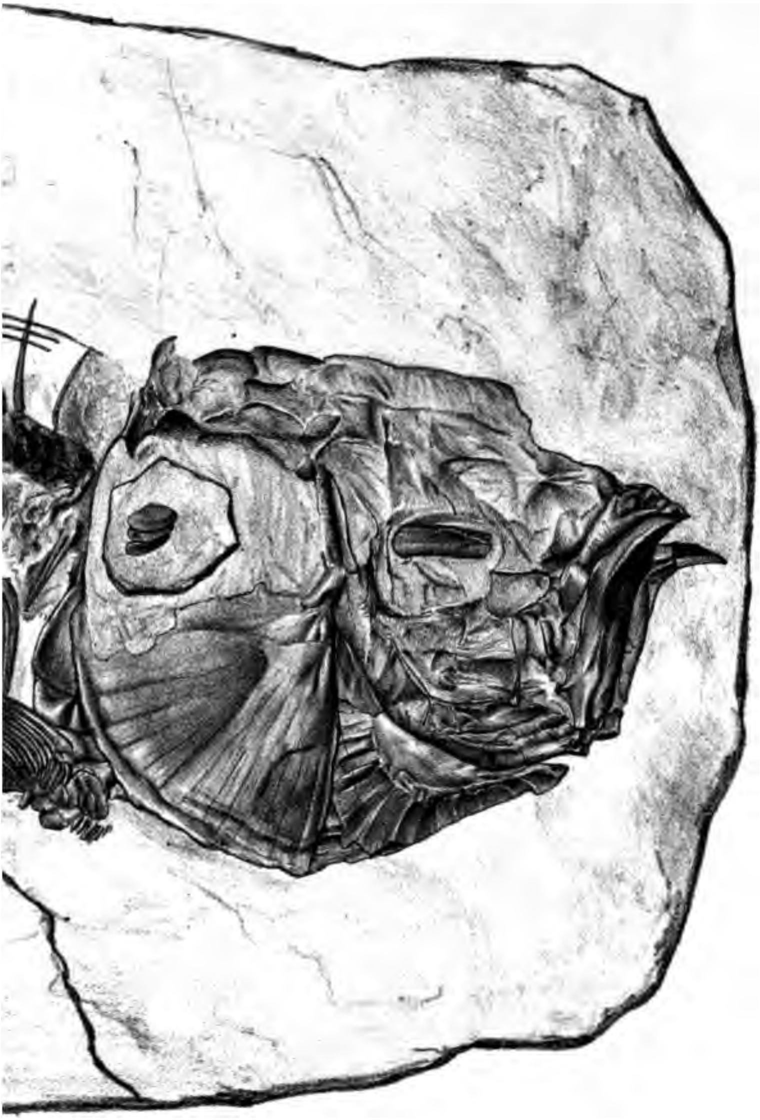

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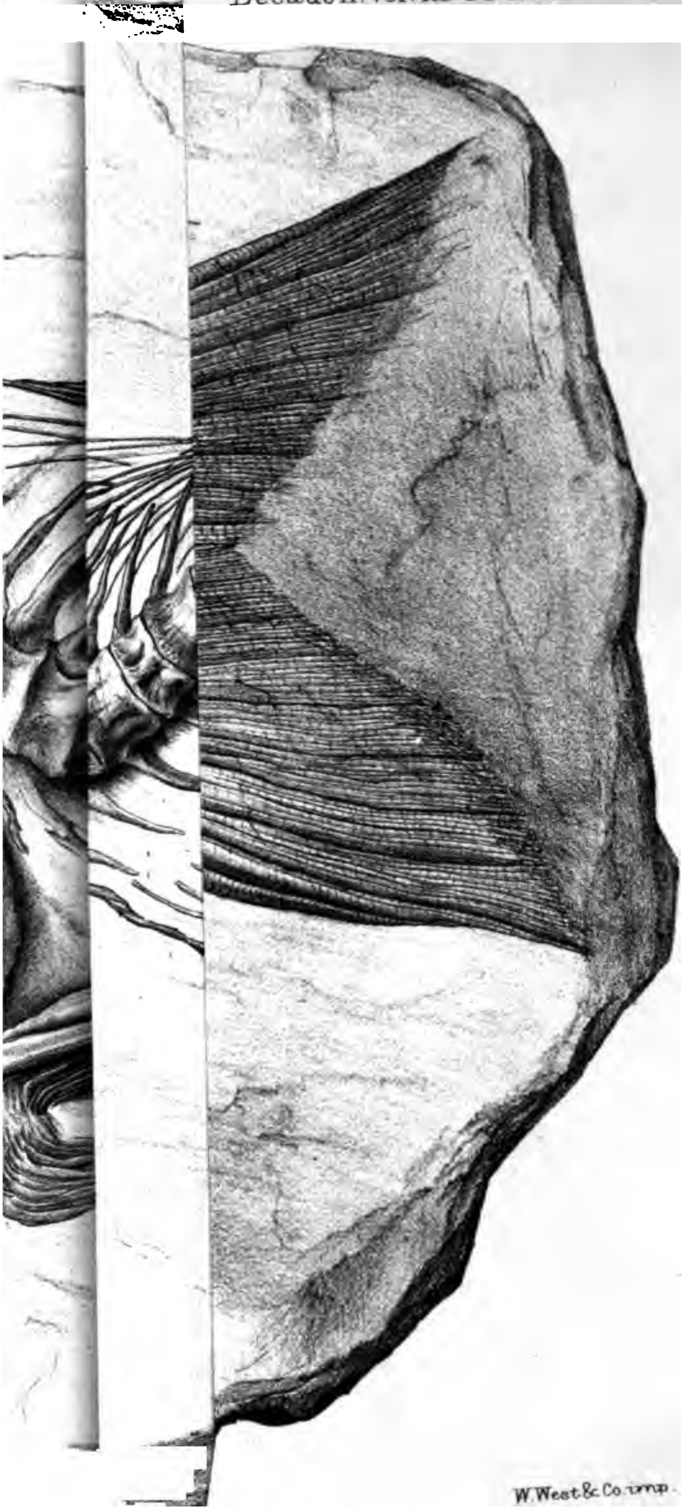

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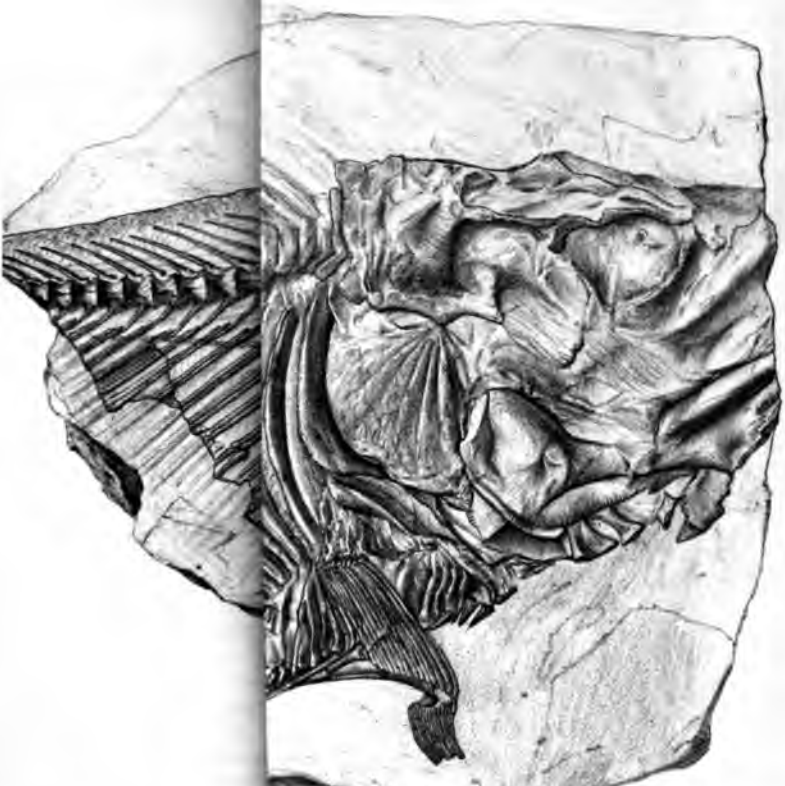

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THE

EOLOGICAL MAGAZINE.

NEW SERIES. DECADE II. VOL. III.

No. X.—OCTOBER, 1876.

ORIGINAL ARTICLES.

—Contributions to our Knowledge of the Fish-fauna of the Tertiary Deposits of the Highlands of Padang, Sumatra.

By Dr. Albert Günther, V.P.R.S.,
Keeper of the Zoological Department, British Museum.

(PLATES XV.—XIX.)

HE Geological Magazine for October, 1875 (pp. 477-486), contains an article "On the Geology of Central Sumatra," by rr R. D. M. Verbeek, Superintendent of the Geological Survey of t island, in which the position of the fossiliferous rocks of the ghlands of Padang is sketched in a manner as clear as concise, and ich must be consulted by those who desire to understand the læontological age of the fossils described in this paper.

The specimens were collected by Herr Verbeek, and transmitted Prof. T. Rupert Jones, F.R.S., by whom they were placed in my nds for examination and comparison with the materials in Europe. l are from Tertiary deposits; and more especially from the Marl-tes, marked 5 *a* in Herr Verbeek's diagrammatic section, and from Carbonaceous shale of 5 *b*. Those from the latter deposit are in a st fragmentary state—only teeth, spines, and some of the harder nes being preserved; and it would appear that the Fishes did not e actually at the locality where this deposit was formed (may be, t of the low vegetation of a bog), but that fragments of them re carried there by some agency. The fossils from the Marl-tes, on the other hand, are in a very good state of preservation, st of the bones being in their natural position and connexion, d even tender parts, such as the fin-rays, being still perfect. e incomplete condition of a part of the specimens is due rather to idents during or after their removal from the deposit, and to the dy exfoliation to which the matrix is subject.

With regard to their systematic position, these Sumatran fossils nd in the same relation to the recent Fish-fauna of the island, as se of the Brown Coal of Bonn to their successors in recent times. e majority are generically identical with the living forms occurring the island at the present time; some may be referred to genera herto not found in Sumatra, but still persistent in remote parts the globe; whilst others belong to genera not recognizable in r recent fauna. However, we have to remember that the recent h-fauna of Sumatra is but imperfectly and partially known; and that the specimens representing this class of animals in Museums are unsuitable for thorough comparison with allied extinct forms, being generally young and of small size. Sumatra offers, for many years to come, a rich field to the Zoologist as well as Geologist.[1]

The following table will show at a glance the geographical distribution in recent times of the fossil Sumatran genera described in this paper:—

1. *Auliscops.*	1 species is known from N.W. America.
2. *Pseudeutropius.*	Several sp. from the Continent of India and Sumatra.
3. *Bagarius.*	1 sp. from the Continent of India and Java.
4. *Thynnichthys.*	2 sp. from the Continent of India and 2 from Sumatra.
5. *Barbus.*	Numerous species all over India.
6. *Amblypharyngodon.*	3 sp. from the Continent of India.
7. *Hexapsephus.*	Known from Sumatran fossil only.
8. *Notopterus.*	Several species from the Continent and Sumatra.
9. *Chirocentrus.*	1 sp. from the Indian Ocean.

I.—FOSSILS FROM THE MARL-SLATES.

Auliscops sumatranus. (Pl. XV. Fig. 1.)

One species only of this genus has hitherto been known. It occurs on the north-west coast of America, and has been found in salt-water; however, it is a well-ascertained fact that the species of *Gastrosteidæ*, to which *Auliscops* is allied, readily change their habitat from fresh- to brackish- and even salt-water, and *vice versâ*. *Fistularia* likewise enters fresh-water. As far as the characters of the genus *Auliscops* are known, there appears to be no reason why the Sumatran fossils before us should not be referred to it.

The snout is comparatively short; the centres of the vertebræ are not grooved on their abdominal surface, as in *Fistularia* and *Aulostoma*; the dorsal and anal fins are short; the caudal is rounded, without prolonged central ray; there is a series of anterior dorsal spines; the interneurals are horizontally situated, forming together one continuous bony strip; and there are no external pubic shields.[2]

Five specimens of this fish are in the collection.

a. The largest is 14½ inches long, showing scarcely more than the general outline of the fish. The interneural strip is well shown, likewise the number of the neural spines, but the centres of the vertebræ of the abdominal portion are destroyed.

b. This specimen (which is figured) is 11 inches long, and is best preserved of all. The snout lies on the side; behind the the skull is twisted, so that its base is visible. Also the ominal column of vertebræ shows its ventral aspect, the neural ies being so bent as to lie in the same plane as the parapophyses. › right and left series of parapophyses have become detached n the vertebral column, both lie along the right side of the cimen; and still more outwards, towards the left, a series of 21 sal spines has left a somewhat faint impression. The caudal tion, with the fins, lies on its side.

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[1] The manuscript of this paper had been delivered to the Editor, when Mr. Griesbach drew my attention to a paper on "Fossile Fische von Sumatra" by Dr. W. v. d. Marck, Palæontograph. 1876, April, pp. 405-414, pls. 23 and 24. As the materials in the British Museum were much richer than those at the disposal of that author, I had nothing to alter in my manuscript, with the exception of the specific name of the most common fish of this formation, viz. *Thynnichthys amblyostoma*. Through Dr. v. d. Marck's paper I became acquainted with Prof. Rütimeyer's "Bemerkungen zu den fossilen Fischen von Sumatra" (Abhandl. Schweiz. palæont. Ges. i. 1874). To judge from his description, I think that the fish named "*Smerdis*" by him, will prove to be an *Ambassis*, a genus very common in the fresh-waters of the Indian region. The so-called *Dussumierina* appears to me to be fry, and, at present, indeterminable.

[2] We may remark here that the skeleton figured by Agassiz, in Poiss. foss. vol. iv. tab. xxxv. fig. i., under the name of *Aulostoma chinense*, is not that species or even genus, but *Fistularia tabaccaria*.

Ve see from this specimen that the snout was not much longer n the remainder of the head (1¾ inches). Some of the foremost tebræ were confluent into one piece, equal in length to the three owing vertebræ. The abdominal portion consists of 27 vertebræ, h compressed centres, not grooved along their ventral surface. e caudal portion consists of 31 vertebræ, much shorter than those the abdominal portion; 12 of them are in front, 5 below, and 14 ind the dorsal. The soft dorsal consists of 9 or 10, the anal 8 or 9 rays. The caudal is short, with feeble rays and rounded terior outlines. The dorsal and anal are highest in front.

)n the left-hand side of the posterior part of the head there is ible a flat, sub-crescentic bone, anteriorly with a projecting artiar process, from which a gently curved ridge runs along the ole length of the bone. The surface is finely granulated, the nules being partly arranged in radiating striæ. I consider this be the operculum.

:. The impression of the anterior half of the body of a specimen aller than the preceding.

l. The anterior portion of the specimen, of about the same size as cimen *a.*

:. The impression of a fish six inches long.

This fish is probably the one determined by Prof. Geinitz as *tularia kœnigii,* Agass. (see GEOL. MAG. 1875, p. 481); but our 1 has the central caudal ray not prolonged, and therefore does not ong to *Fistularia.*

This is evidently the same fish which has been described and ured by Dr. W. v. d. Marck as *Protosyngnathus sumatrensis.* The cimens in the British Museum appear to be in a better state of servation than those examined by that palæontologist, and, theree, better adapted for the determination of the affinities of this h.

Pseudeutropius verbeekii. (Pl. XV. Fig. 2.)

The following description is chiefly taken from two specimens in › collection, of which one, if complete, would have been about ie inches long; only a very indistinct impression of a part of the ad is preserved. From the dorsal fin backwards this specimen, iich lies on its side, is in tolerably good condition. The second ecimen lies on its back, and is only 6½ inches long. Other ger examples are more fragmentary, and do not assist much in e examination of this species.

Nothing can be said of the form of the head, except that it appears to have been rather elongate, with the upper surface of the snout granular. The caudal portion of the vertebral column consists of 27 vertebræ; of the abdominal portion 11 can be distinguished—the entire number consisting probably of about 14.

The dorsal fin consists of a strong, smooth spine, and seven rays. It is inserted at a short distance behind the head, opposite to the fifth to eighth vertebræ. The length of its spine is equal to the length of the thirteen last vertebræ.

The anal fin is low, consisting of twenty-eight short rays. It is supported by interhæmals, which are longer than the fin-rays, and attached to the hæmals, so that two always correspond to one hæmal. Caudal very deeply forked, the length of one of its lobes being equal to that of the nineteen last vertebræ.

Pectoral spines about as long and strong as that of the dorsal fin, strongly serrated. Ventral fins inserted immediately behind the dorsal, consisting of seven rays.

An example in a very fragmentary condition, figured by Dr. W. v. d. Marck under the name of *Brachyspondylus indicus*, probably ought to be referred to the present species. A glance at the geographical distribution of the species of the genus *Pseudeutropius* will account for my retaining the specific name given by me, in the place of that of *indicus*.

Bagarius gigas. (Pl. XVI. Fig. 1.)

A large siluroid of the group *Bagariina*, and probably belonging to the genus *Bagarius*, is represented by some remnants of the humeral arch, and a nearly perfect pectoral fin; other portions of the skeleton, such as the branchial apparatus, ribs, etc., being too much broken and confused for more detailed description. The pectoral fin is sickle-shaped, apparently consisting of eleven rays, the first of which is extremely strong and long; rather more than its terminal half is closely articulated, and indistinctly denticulated behind. It is 5¾ inches long, and ½ inch broad in its widest part. The humerus is distinguished by the absence of prominent ridges, and of the granulation on the more superficial parts, which evidently were covered by skin. Its symphysial portion is tapering, showing that the union with its fellow must have been short and loose.

Thynnichthys amblyostoma. (Pl. XVII.)

The remains of this fish appear to be very common in this stratum. There are four apparently adult examples, three of middle size, and three young ones. The largest has a length of 12½ inches. All lie upon their sides, the head being so much crushed, that only a few of the opercular bones and fragments of one or two of the others can be recognized *in situ*. Of the vertebral column nearly the whole (with the exception of the foremost portion) can be made out distinctly, the ribs and scleral spines being rather confused. The fins are sufficiently well preserved to ascertain their structure and position.

The genus *Thynnichthys* is characterized by a peculiar shape of the head, the eye being far below the upper profile and the opercules;

rge and firm opercular bones; a short dorsal fin, without osseous ines, and opposite to the ventral fins; a short anal; compressed iaryngeal teeth in three series, and truncated at the top. Such e the characters of this genus which we may expect to be sible in fossil remains, and in which, indeed, the fossils before us ree with the recent species of *Thynnichthys.* The peculiar shape the mouth of the latter is, however, entirely destroyed in the ssils.

The following parts can be more fully described. The head was rge, its length being considerably more than one-half of the length the vertebral column. The lower jaw was obliquely directed wards. The margin of the præoperculum, which was not covered the skin, is wide, deeply ribbed with muciferous channels, radiat- g towards the edges. The upper and lower limbs of this bone are ual in length, and meet at a right angle, which, however, is unded off. Operculum very large, striated in its lower half.

As regards general structure, the vertebræ do not differ from those the genus *Barbus,* those in the middle and posterior portions of e column being rather deeper than long. Fifteen or sixteen belong the caudal portion of the column; thirteen or twelve may be counted tween the first attachment of the interhæmal of the anal and that of e first interneural of the dorsal fin; the foremost part of the column parently consisting of seven or eight vertebræ, so that the total mber of vertebræ does not seem to have exceeded thirty-six. The urals of the anterior vertebræ were of moderate strength and ight (18 millimetres), equal in length to three and a half of e middle vertebræ. The scleral spines were numerous, forming ndles attached to the middle of the neurals and hæmals of the idal vertebræ, and lying in the direction of the longitudinal axis the body. The ribs do not show any peculiarity as regards form size.

The dorsal fin consists of three simple and nine branched rays, e third and fourth rays being the longest, about two-thirds the igth of the head; its origin falls vertically before that of the ntrals, nearly midway between the end of the snout and the root the caudal rays. Anal very short, and only about two-thirds as gh as the dorsal; it consists of three simple and five branched ys. Caudal fin deeply forked; the length of the upper lobe being t much less than that of the head. The pectorals appear to have tended to, or nearly to, the root of the ventral fin.

In one specimen only remains of the pharyngeal apparatus could found. They are *in situ,* and consist of three polished closely pressed laminæ, in which the crown is still cutting, not worn wn by use.

This fish has been described and figured by Dr. W. v. d. Marck a Clupeoid, *Sardinioides amblyostoma.* However, there can be no ubt as to its belonging to the *Cyprinidæ.*

Barbus megacephalus. (Pl. XVIII.)

This fish is represented by a single specimen, 23 inches long. It is fficiently well preserved to ascertain the general form of the head and body, the position of the fins, the structure of the mouth, and the number of fin-rays and vertebræ. With regard to its generic affinity, I am guided in its determination chiefly by the form of the head, and by consideration of the generic composites of the recent fauna of Sumatra. All trace of barbels has disappeared; and the pharyngeal teeth are hidden in the confused mass of the crushed bones of the head.

The head is very long (7 inches), about $\frac{2}{5}$ of the length of the vertebral column, formed of strong massive bones. The snout was particularly long; the eye being situated nearer to the posterior than to the anterior end of the head, close below the upper profile. The maxillary, inter-maxillary, and mandible are strong bones; showing that the cleft of the mouth was of considerable width, but did not extend to the eye.

The vertebræ are higher than long, in fact, short. Eighteen belong to the caudal portion of the column; thirteen may be counted between the attachment of the first interhæmal of the anal, and that of the first interneural of the dorsal fin; the foremost part of the column apparently consisting of ten vertebræ; so that the total number of vertebræ seems to have been about forty-one. The processes and bony appendages of the vertebral column do not show any peculiarity requiring detailed description.

Neither the dorsal nor the anal fins are armed with an anterior thickened spine. The former consists of three simple and nine branched rays; the longest of which is not quite half as long as the head. The origin of this fin is considerably nearer to the root of the caudal, than to the end of the snout, but little in advance of the root of the ventral. Anal fin very short, about $\frac{2}{3}$ as high as the dorsal, consisting of three simple and five branched rays. Caudal deeply forked; the length of its lower lobe being about $\frac{2}{3}$ of that of the head.

The pectorals are not well enough preserved to allow us to judge of their length; but the ventrals were evidently very well developed, the length of their outer ray being nearly equal to that of the largest of the anal fin.

Amblypharyngodon, Blkr. (Pl. XV. Fig. 4.)

It seems that the existence of a large species of this genus is indicated by a pair of pharyngeal bones, armed with globular molar teeth in small number. On one of the bones three teeth are still *in situ*, in a single series, the anterior being the largest, the middle about half as large, and the posterior minute.

Chirocentrus (?) *polyodon*. (Pl. XV. Fig. 3.)

Owing to its fragmentary condition, the determination of this fossil is very uncertain. It appears to come nearest to *Chirocentrus*, on account of the great development and form of the teeth of the lower jaw, those of the upper jaw being much smaller. The whole of the mandibulary series of teeth is preserved, with the anterior half of the bone. Of the upper jaw only a fragment and an incomplete impression of the remainder is preserved. The mandibulary s is 45 millim. long, and consists of twenty-three closely-set al slender teeth, of which the two foremost and the twelfth and enth are much stronger than the rest, 10 millim. long. The er portion of the maxillary was armed with a single series of al teeth of about the same size as the small posterior teeth of nandible.

mmon as *Chirocentrus* is on the coasts of the Indian Ocean and ipelago, I cannot without hesitation refer our fossil to this s, which, as far as I know, is a marine form.

Notopterus primævus. (Pl. XIX.)

though no doubt whatever can be entertained as regards the ric affinities of this fish, the specific characters unfortunately be given but very incompletely; the single specimen before us g mutilated in front and behind. It is evidently most closely d to the species now living in Sumatra. The lower part of the perculum and some ridges of the mandible are distinctly ited; the abdominal portion of the vertebral column is short, h shorter than the head, formed by about 13 short vertebræ. y-one vertebræ of the caudal portion are preserved. The al and hæmal spines are of moderate strength and length, ted backwards. The interhæmals are about twice as numerous nd much longer than, the hæmals, generally two of them being hed to one hæmal. The first hæmal and interhæmal are exingly strong, firmly wedged together, and forming the posterior idary of the abdominal cavity. Ribs well developed, extending ly to the lower part of the abdominal cavity. From their exities are suspended the scleral bones, which terminate below in ine, the spines forming the external double serrated edge of the men in this genus. The anal rays are not directly articulated he interhæmals, but a series of shorter and thinner additional s is intercalated between the rays and spines, the number of additional bones being considerably increased above that of the interhæmals, and equal to that of the fin-rays.

he dorsal fin is short and small, its position corresponding to the teenth and fifteenth caudal vertebræ. Pectoral fin moderately, ral but little developed—as usual in this genus. Scales very ll.

he specimen, in its present mutilated state, is 9½ inches long, may have measured 11½ inches when perfect.

II.—FOSSILS FROM CARBONACEOUS SHALES.

Hexapsephus. (Pl. XVI. Figs. 2 & 3*a*, *b*, *c*.)

n the Tertiary coal-beds of Padang, conical or mammilliform h, up to the size of a large pea, are of not uncommon occure; their determination would have been a matter of great culty; but, fortunately, one or two slabs have been preserved, wing these teeth in their serial connexion, and attached to a e. which, without any doubt, is the pharyngeal bone of a Cypril fish. Not knowing of any living Cyprinoid with teeth of similar form and arrangement, I am obliged to refer these remains to a distinct genus.

The pharyngeal bone is of the usual shape, 26 millim. long, armed in its concavity with a single series of three large teeth, each of which differs from its fellows in form. As isolated teeth, but of much larger size and more perfect, are available for examination, I take the description from them.

The hindmost tooth is of conical shape, with the apex excentric, directed towards the second or middle tooth. The greatest diameter of its base is 10 millim. long, the transverse diameter 8, and this is also its height. It reminds us in its general form of that common shell, *Lepeta cæca*. The second tooth has more the shape of the molar of a carnivorous animal. On its crown it is provided with three tubercles, or rather with two longitudinal ridges, of which the outer one is divided by a notch into two tubercles, the more prominent of which is that nearest to the first tooth. This tooth is 9 millim. broad, 6 long, and 9 high. The last tooth is the smallest, much compressed in the longitudinal axis of the dental series. Its upper surface is much ground down, it is only 5 millim. high and 4 wide. A comparison of these large teeth with those attached to the pharyngeal, shows that this Cyprinoid must have attained to as great a size as any of the living species; the pharyngeal may have belonged to a fish 10 inches long.

Besides this fish, there are from the same deposits several dorsal and pectoral spines, evidently belonging to the Siluroid described above as *Pseudeutropius verbeekii*; also some isolated Cyprinoid bones, which, however, are of too general a type to be specifically determined, or to require more than this passing notice.

Finally, I have to add that Dr. W. v. d. Marck describes and figures the posterior portion of a vertebral column under the name of *Brachyspondylus saropterix*. It appears to me to have belonged to a Cyprinoid fish, but I would not venture to define more nearly its affinities. The presence of nine branched rays in the anal fin may serve as a guide as regards the group, to which this fish ought to be referred.

EXPLANATION OF PLATES XV.-XIX.

PLATE XV. FIG. 1. *Auliscops sumatranus*, Günther.
„ 2. *Pseudeutropius verbeekii*, Günther.
„ 3. *Chirocentrus* (?) *polyodon*, Günther.
„ 4. *Amblypharyngodon*, Blkr.
„ XVI. „ 1. *Bagarius gigas*, Günther.
„ 2. *Hexapsephus*, sp. nat. size, pharyngeal bone, with three teeth *in situ*.
„ 3*a*. *Hexapsephus*, pharyngeal teeth.
„ 3*b*. „ „
„ 3*c*. „ „
„ XVII. *Thynnichthys amblyostoma*, Marck, sp. (This figure is drawn from two examples as indicated by the line of fracture.)
„ XVIII. *Barbus megacephalus*, Günther.
„ XIX. *Notopterus primævus*, Günther.

,—NOTICE OF *HARPACTES VELOX*, A PREDACEOUS GANOID FISH OF A NEW GENUS, FROM THE LIAS OF LYME REGIS.

By Sir PHILIP GREY-EGERTON, Bart., M.P., F.R.S.

|OME years back the Earl of Enniskillen obtained a specimen of) a fossil fish, found in the rich ichthyological treasury of the Lower as at Lyme Regis, which proclaimed itself at first sight to be an tirely new form, differing generically from all the previously- own fishes of the Mesozoic period.

Although the outlines of the fish are clearly delineated, without ilocation or distortion, the majority of the component members are her altogether wanting, or so indistinctly preserved, that, being erse to overhaste in thrusting new names upon the Palæontological t, I deferred publishing any description, in the hopes that some ther evidence might be forthcoming to bridge over the deficiencies the type. How often have I cherished similar hopes, and how en have they been disappointed!

The Liassic genera—*Ctenolepis, Legnonotus, Nothosomus, Endactis, rissonotus*, and *Isocolum*, still remain, after years of anxious ex- station, each exemplified by one type-specimen!

Warned by this experience, I am tempted to offer to the Editors the GEOLOGICAL MAGAZINE a cursory description of this specimen, isidering it not impossible that by so doing I may draw the atten- n of the numerous collectors of the present day to the leading tures of this type, and so induce them to make public any terials they may chance to have bearing upon the subject of the sent memoir.

The features which strike the beholder most forcibly on inspecting s specimen are, the great disproportion of the length, compared th the depth of the body, and the excessive proportions of the idal fin. The direct measurement from the snout to the spring the caudal fin is 2 feet 10 inches, while the greatest depth of the ink is barely 5 inches. The head measures 8 inches from the se to the thoracic girdle. The dorsal fin is placed directly above ventral fins, nineteen inches from the snout. The anal fin is d-way between the ventral fins and the base of the tail, twenty- en inches from the snout. The head is in the form of an elon- ed cone, the most effective figure for cleaving the water. The nponent bones are much dislocated. One ramus of the mandible thrown up and seen from below, the dentary margin being con- led or absent. The vomer is nearly *in situ*, a little moved on one e, so as to display a close-set group of small conical hooked teeth ich invested its palatal surface. Below the head is seen a large nmetrical oval plate of bone, measuring 3 inches by 2 inches, ich I take to be a single jugular or glossohyal bone. The oper- ar apparatus appears from the contour of the head to have been moderate dimensions, but the parts in this region are defective. ere is evidence, from some impressions left on the matrix, that at events some of the bones of the head had an ornamental cover- of ganoine, more or less granular in pattern. The position of pectoral fin is only indicated by a few scattered rays, showing no remarkable feature. The dorsal fin is represented by the base and the extremity, all the intermediate portion being destroyed. It was evidently a large organ, adapted for preserving the equilibrium of the body; and it is fair to presume, from the study of other parts of the fish, that it was strengthened by fulcral rays on its anterior margin. The ventral fins are composed of numerous rays, which remain single for an inch or so from the base, but are subsequently frequently bifurcated and closely cross-jointed. The anal fin is only represented by a few fragmentary rays. The caudal fin was an organ of extraordinary power. The pedicle or base is massive; from this the lower lobe springs, measuring 8 inches in length. It contains about 30 strong rays, very much dichotomised, and with numerous cross-joints—a construction calculated to give great flexibility to the organ. The upper lobe springs from the terminal vertebræ of the spinal column, which are turned abruptly upwards, simulating heterocercy, but they do not extend into the upper lobe of the organ. These are the only ossified portions of the skeleton seen; the spinal economy being probably notochordal. The upper margin of the tail is furnished with a series of fulcral spines or elongated scales, short and thick at the base of the fin, but tapering gradually in succession as they ascend upwards. A more delicate fringe borders the lower lobe. The extremity of the tail is not preserved, but by continuing the converging outlines of the upper lobe the result would be at least two inches in excess of the termination of the lower lobe, or ten inches from base to tip. A few scales are preserved in the vicinity of the ventral fins. They are characterized by a somewhat irregular granular design, the granules becoming in places confluent. A somewhat larger dislocated scale occurs at a distance from those seen *in situ*, and an opercular plate; but as the surface-markings on these remains are so different from those ascertained to have belonged to the fish, I hesitate to consider them as appertaining to it.

From these details I am inclined to infer that the fish was a true Notochordal Ganoid, more nearly allied, perhaps, to *Eugnathus*, than to any other known genus, although the position of the fins is different.

That it was a predaceous fish, and endowed with abnormal natatory power, is clear from the contour of the body, lythe and lanceolate, and the great expanse and strength of the tail, which would propel the monster with the velocity of a rocket through the water, giving small chance of escape to the luckless denizens of the Liassic sea which constituted his daily food.

Oulton Park, *Sept.* 12*th*, 1876.

III.—The Climate Controversy.

By Searles V. Wood, Jun., F.G.S.

(*Concluded from the September Number*, p. 398.)

No. 4.—The cause suggested under this head was the favourite theory of Sir Charles Lyell. That the existing climates are materially influenced by the distribution of land and water, and by the direction of the great ocean currents, physicists and geologists agreed. It was the view, however, of Sir Charles, that these ditions were of themselves alone adequate to account for all nges of climate which the earth has undergone, though in his st editions of the "Principles of Geology" he admitted that ɜr causes have probably contributed. In this work he gave ginary representations of such a distribution of land and water r the globe as, in his view, would produce the extreme of heat the extreme of cold. In that intended to represent the extreme ıeat, the land is all collected in low latitudes on either side of Equator, so that the higher latitudes and polar regions are ıpied entirely by the ocean; while in that intended to represent extreme of cold, these conditions are reversed. Mr. Croll, however, in his late work on "Climate," contends that precisely opposite ılts to those supposed by Sir Charles would flow from such arrangeıts of land and water, since the occupation of the equatorial ; by land would prevent the formation there of those great rents of warm water, which, by transferring heat from the lower tudes to the higher, and to the polar region, mitigate greatly the mal cold of those parts of the earth.

'he preponderance of glacial conditions in the present Antarctic ions over those in the Arctic was attributed by Sir Charles to the ımulation of land, and particularly of high land, within the Ant- ic circle. The glimpses obtained by Sir James C. Ross's expe- on of the mountains cutting the distant horizon behind the pendicular ice-wall, which was found by that expedition to ɜnd for hundreds of miles in very deep water, lead to the belief ; some of the Antarctic land which lies beneath the vast mass of whose seaward termination forms this wall, must rise to great tudes; while the two great volcanos discovered by that expedi- . in the same region, by their great altitude, point to the same rence. In the Arctic region the only lofty land which has been overed, notwithstanding that much of this region has been pene- ed in various directions, while the Antarctic has remained enetrable, is that of Spitzbergen;[1] the influence of which is so ıtly modified by the impact of the Gulf-stream on its western ıts, that Spitzbergen, though covered with great glaciers, is not ıpletely sheeted with ice like Greenland, which lies in lower ude by several degrees; and there is every reason to suppose ; the elevation of Greenland beneath its icy mantle is, even in its rior, far below that of Spitzbergen. Besides this, the Antarctic ion does not appear to be penetrated by any great current carry- warm water from the tropics, as is the Arctic; and the great sheet which surrounds the Antarctic Pole, stretching far beyond limits of the land, has its terminal wall in very deep water, appa- ly on all sides around the Pole. The drift of the bergs which break from this wall is thus, though slow, unchecked by shoalness of er (by which the greater part of the Arctic bergs are arrested il they waste away), or diverted by the incidence of a powerful current from lower latitudes, like the Gulf-stream, so that they have been met with in vast chains extending beyond the visible horizon. Thus they help to refrigerate the climate of latitudes lying between the polar circles and the limit of their drift, which extends almost as far as the latitude of the Cape of Good Hope; and it is to this cause that the advocates of the Geographical theory of climate mainly attribute the lower temperature of the higher latitudes of the southern hemisphere, as compared with similar latitudes of the northern. The present colder condition of the Antarctic region and of high southern latitudes is thus appealed to by the advocates of both theory No. 3 and theory No. 4; by the former on the ground that the aphelion point now occurs during the southern winter, and on the ground, also, that this region furnishes evidences of the cumulative tendency of ice and snow; and by the latter on the ground that it offers the most striking evidence of the influence of geographical causes on climate.

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[1] Possibly the lately-discovered Franz Joseph Land may also prove to be part of Arctic highland.

Sir Charles Lyell, in concluding his argument in the "Principles," in support of the sufficiency of geographical causes, observed, "that if at any former period the climate of the globe was much warmer or colder than it is now, it would have a tendency to retain that higher or lower temperature for a succession of geological epochs." This, he considered, "would arise from the great depth of the sea as compared to the height of the land, and the consequent lapse of time required to alter the position of continents and great oceanic basins." It is difficult to reconcile this view with the intercalation of glacial beds in the Permian formation of Britain and in the Eocene and Miocene of Switzerland and Italy, to which he seemed to attach credence.

If geographical distribution were sufficient to account for all the changes which have taken place in climates, then, by coupling with it, as Sir Charles Lyell has done, a decrease in the obliquity of the Ecliptic, so as to diminish the polar circles and thereby abridge those periods of darkness which, according to some geologists, present an insuperable difficulty in relation to the fossil vegetation of Greenland and Spitzbergen, we should appear to make some progress towards an explanation of the puzzle presented by the presence of that vegetation; but even in that case we should, as already mentioned, have to assume a very much greater variation in the obliquity than astronomers will concede, in order to meet the case of such very high latitudes as Spitzbergen. We should also have to satisfy ourselves that Mr. Croll's contention that a decrease in the obliquity would increase the cold of the polar regions was unfounded; because, if otherwise, that decrease would neutralize any increase produced in polar warmth by geographical changes; and so leave us without this essential desideratum for the growth of the vegetation in question.

As the influence of geographical causes, to a certain extent, on climate is admitted by every one, from the features presented all over the world, though the application of them in accounting for the great changes in geological climates is disputed, it is not worth

le to pursue the subject further into details; because, if we
ıt the largest concessions to this theory, two apparently insuper-
ı difficulties seem to me to present themselves to it as an expla-
on of the Glacial Period proper. One is that the probabilities are
:mous against these changes having simultaneously taken place to
ıxactly similar degree in both hemispheres, so as to produce an
arently equal increase of glaciation, or, to be more accurate (as
do not know the immediate pre-glacial geology of the southern
ıisphere), against their having simultaneously passed away to a
ilar degree in both; and the other is the difficulty to which reference
been already made in considering cause No. 3, viz. the existence
he same differences between the limits of glaciation in Europe
eastern North America, during the Glacial Period, as prevail
veen corresponding latitudes in those countries in respect of
ter cold at the present day.

t may be worth while, however, before leaving the subject of
4, to notice that, in reference to the higher temperature of the
cene climate, we seem to find that presence of equatorial land
ch the theory of Sir Charles Lyell would demand as its cause,
:he wide stretch of continent which we have every reason to
eve extended at that time through the Indian Ocean, and which
may suppose formed about that period the place of man's origin;
round the sunken site of which the lowest existing races of
ı are now found grouped.

Io. 5.—The cause suggested under this head, a change in the
h's axis, was naturally the first which would occur to geologists
liscovering, as they did almost at the outset of their science, the
lences of a warmer climate having in past ages prevailed in
se countries where their investigations were originally pursued.
ı concurrence of opinion among astronomers, however, that if any
nge had taken place in the axis of rotation, traces of it would have
n left which they could detect, but did not, induced this theory to
generally rejected. It was, however, revived some few years ago by
John Evans. in a memoir read before the Royal Society, and has
n again touched upon by him in his late Presidential Address
the Geological Society of London. In his memoir Mr. Evans,
ırder to meet the objections raised by astronomers to any altera-
ı in the axis of rotation, suggested that the exterior shell of the
h might be comparatively so thin that, resting on a fluid nucleus,
lided over it; so that all parts of the surface might undergo
nges in relation to this axis, without the position of the axis
tively to the spheroid as a whole being changed. In his late
lress, however, he discusses the possibility of a change of axis on
erent grounds, quoting the opinion of the late Sir J. W. Lubbock,
t if from any cause the axis of rotation did not coincide with the
ı of figure, the pole of the axis of rotation would describe a spiral
nd the pole of the axis of figure until it became identical with
He then adverts to the great depth which the late deep-sea
estigations have disclosed, as stretching over a great portion of
equatorial oceans, and suggests that these show that the equa-

torial diameter of the more solid part of the globe may at once be reduced by nearly six miles, over four-fifths of its circumference; that is to say, the usually accepted equatorial protuberance of the earth may be reduced from 13 to a little over 10 miles, which amounts to a reduction of six miles in the equatorial diameter. Coupling this with the existence in the northern hemisphere of large tracts of land ranging continuously some thousands of feet above the sea-level, he thinks that the spheroidicity of the globe, on which the stability of the pole has been held to depend, may be regarded, even at the present time, as considerably less than is usually supposed. He then refers to the formation of mountain chains, the elevation and submergence of continents, and the wearing away and transport of their materials during geological time, which he urges must cause changes in the solid crust of the earth, by which its figure must be undergoing slight but continual change, so as to acquire a new axis, and thereby cause a constant change in the axis of rotation; and he even suggests for the consideration of mathematicians a certain supposititious elevation and depression of tracts of the earth's surface, which he defines, and which he thinks would alter the axis of figure and bring it 15° or 20° south of the present, and on the meridian of Greenwich; and he asks whether, if so, the axis of revolution would not eventually correspond with it?

Mr. Evans insists on the contradiction offered by the fossil vegetation of Spitzbergen to the possibility of its having lived while the position of the earth's axis subjected that country, as it now does, to a long period of darkness. The statement of Professor Nordenskiold, that he was unable to discover among the thick succession of Miocene deposits in that country which yield the remains of this vegetation any traces of ice-action, adds to this contradiction; because, until this, it was conceivable that the vegetation in question, though not forming such a flora as now lives in countries subject to very severe winters, as, for instance, that of Canada, might nevertheless have by degrees become adapted to a winter of this kind; and by thus remaining torpid through the season of darkness have been unaffected by it. Such an hypothesis, however, Professor Nordenskiold's statement seems to put out of the question. But for this absence of any indication whatever of winter cold, Mr. Croll's contention that an increase of obliquity would cause an increase of summer heat, were it sound, and there were conceded the possibility of a large increase in the obliquity of the ecliptic, might furnish an explanation of vegetation in high latitudes; although such increase would somewhat lengthen the periods of darkness of those Greenland latitudes lying near the edge of the Arctic circle which have furnished the remains of a similar vegetation. As the case, however, stands, we can find no refuge in such an hypothesis, were it otherwise tenable.

Supposing, however, that the mathematical objections, which, perhaps, require re-examination, were removed, there are some objections to the theory of a change of axis from a geological point of view. If, for instance, such a change be the true cause of changes in climates, then, considering how much the attempt is facilitated by the large proportion of the earth's surface which is occupied by the ocean, and by those vast tracts of continent of which we have no geological knowledge, such as most of Africa and High Asia, it ought not to be difficult to find a supposititious axis of rotation for every one of those five periods when Greenland or Spitzbergen must have possessed climates represented by existing latitudes below 40°, viz. the Carboniferous, the Triassic, the Jurassic, the Cretaceous, and the Miocene. This axis would require to be so placed that the various localities over the world, from which fossil organic remains of these respective periods have been obtained, should also all fall within 40° of latitude on either side of the supposititious equator; because the climates indicated by them appear, so far as these remains furnish evidence, to have been all of them such as now prevail within those limits. It would be an interesting test if any one would be at the pains to collect all the notices in British and foreign publications relating to these five periods, respectively, in different parts of the world during the past fifty years, and, taking a terrestrial globe, try to find an axis of rotation which would bring these various parts of the world within such limits of supposed latitude. So far as a very crude and perfunctory attempt which I have made to do so enables me to judge, I do not think that it would be found easy to define such an axis.

If, however, such could be defined, then, unless the polar circles of this axis fell within the area of existing sea, future discoveries ought to disclose that all the formations of these several periods within such circles exhibited evidence of exclusively Arctic conditions.

Again, if we take the Glacial Period proper, the evidences preserved of it seem to show that the Earth passed through it while the axis was in its present position; for although the evidences of this period in the south are confined to New Zealand and South America, and those in the north are, as yet, far from having been carried across the great continents, they nevertheless raise a strong presumption of this identity of axis having been the case.

The difficulties presented by the features of the British, French, and other Miocene, Oligocene, and Eocene deposits to the existence of glaciers descending to the sea in Northern Italy and Switzerland during the Eocene and Miocene periods, would hardly be removed by a supposed change in the axis, as not only should we have the contradiction of tropical or subtropical conditions prevailing within a very few degrees of latitude of these so-called Glacial beds, but the anomaly of the formations with which these beds are associated in Switzerland and Italy furnishing no indication of such a gradual change in their fauna and flora, as the gradual shifting of the Arctic circle down to those countries might be expected to produce, would be left unexplained.

It is presumed, also, that a change in the axis of rotation would produce one in the obliquity of the Ecliptic, so that cause No. 2 would in that case combine with the one now under consideration;

but as there seems so much uncertainty as to the results which would flow from an alteration in the obliquity, the difficulty of forming any idea as to the change in the climate of any given spot of the Earth's surface from a given change in the axis of rotation appears to be great.

No. 6.—The cause suggested under this head, that of variations in the Sun's heat, has had the advocacy of Professor Balfour Stewart. The theory derives support from the spectroscopic researches made of late years into the constitution of the Sun and fixed stars; and more particularly from the circumstance that a sudden increase in the brilliancy of one of the latter some few years since was discovered, by means of the spectroscope, to be due to an outburst of incandescent hydrogen; that is, to an outburst of the element which constitutes the rose-coloured prominences observed on the Sun's limb during eclipse. These outbursts of hydrogen are believed to be identical with the spots on the Sun; and these spots are so far connected with climate, that some astronomers are inclined to the belief that Mr. Meldrum's theory of their frequency being connected with corresponding periods of Cyclone frequency has some foundation. If variations in these outbursts can be connected in ever so slight a degree with meteorological phenomena, it is a legitimate inference that far greater variations, extending over prolonged periods of time, may have had proportionately greater, and longer continued influence upon the meteorological conditions of the Earth's surface; in other words, on Climate. If the view entertained by geologists (until the discovery of beds alleged to exhibit evidences of glacial conditions in various old formations raised contrary ideas), that a generally warmer climate prevailed during geological periods prior to the Glacial, were true, we should, in the theory under consideration, regard the Sun as having undergone at a very late period of the Earth's history an abnormal reduction of its heat-emitting power, from which it is now slowly recovering. So far as regards these alleged glacial deposits of remote geological periods, abnormal reductions in the Sun's heat at those periods would seem as legitimate a cause for them as any other to which they have been assigned; but the same geological difficulties and contradictions which beset these alleged deposits, and raise so much doubt as to their being really due to glacial action, would be as inexplicable under the theory we are considering, as under any other.

Mr. Croll has objected to it, that this theory would not account for interglacial periods of warmth; but, as it seems to me, without sufficient reason; and believing as I do, and as I have in discussing the Excentricity theory explained, that the English Glacial and post-Glacial beds indicate at most two (and possibly only one) oscillations of climate since the commencement of the Glacial Period, I cannot discover anything in the evidences of that period repugnant to the theory under consideration; for if not merely a few stars occasionally blaze out and shortly after diminish to their former splendour, but many others are undergoing, as is believed, smaller and more gradual changes in lustre, there seems no reason for denying that our Sun may during a long period of abnormal diminution have undergone one or more alternations, which for thousands of years restored it, if not to its normal heat-emitting state, yet partially to that state; and in this partially abnormal state it may still remain.

Another objection raised by Mr. Croll to this theory is, that it could not produce a Glacial Period; because, since a reduction of the Sun's heat would cause a reduction in the evaporation, there would be less snow and rain fall, and consequently less snow and ice to accumulate at the polar regions, and so produce glacial conditions; and he quotes a dictum of Prof. Tyndall that more, rather than less heat from the Sun is required to produce a Glacial Period, what is really needed for that being condensers sufficiently powerful to congeal the vapour generated by the heat of the Sun. Whatever weight there may be attaching to this objection, it seems to me to resolve itself into one connected with the cumulative effect of snow and ice as an agent in producing glaciation; for it is hard to understand that an absolute diminution in the Sun's heat should not be attended with a general refrigerence of the earth's surface, though it were attended, as of course it must be, with a diminished fall of condensed vapour. It seems to me that this diminution would be principally sensible in the amount of rainfall, rather than snowfall; but be this as it may, a diminished snowfall, so far from being a difficulty in the way of the evidences presented by the Glacial Period in Britain, would in my view be the reverse; because, while the height to which the Antarctic bergs rise above the water, coupled with their form, and the known specific gravity of ice, leave little doubt that the Antarctic land-ice from which they are detached cannot be less than 5000 feet in thickness, the evidences presented by the Glacial beds of England show that the thickness of the land-ice which enveloped the northern part of Britain during the Glacial period could not have exceeded a third of this amount. The reasons which induce me to think this are too long to be given here; but I may mention that the Boulder-clay of England, and the huge masses of white marl, or reconstructed chalk, acres in extent, which occur in the mud and silt of the contorted drift of Norfolk, are in my opinion formed of sheets and masses of the degraded material produced by the land-ice transported at the bottom of the bergs and dropped on the sea-bottom. Had these bergs detached themselves from land-ice of such enormous thickness as that for which some geologists have contended, we should require a corresponding depth of water to have floated them, whereas we have no evidence of any submergence in these parts sufficient to allow bergs of greater vertical dimensions than 1500 feet to float.

So far as abridged seasons of darkness are necessary, as some think, to account for the rich vegetation, especially the evergreen forms of tree in high latitudes, the theory under consideration offers no solution of the difficulty; and if the much greater warmth of these latitudes were due to it, we must infer that the temperature of medium and low latitudes would be proportionately increased;

but I am not aware that there is much to show a greater degree of warmth in existing low latitudes during geological periods, than in medium, or in some instances high ones. Dr. Newberry, in his Report on the fossil flora of the Yellowstone and Missouri Exploring Expedition, has objected that the climate to which the Miocene flora of Greenland was due could not have been produced by any cosmical agency, on the ground that, if so, a tropical climate would at the same time have prevailed over those regions lying between 45° and 50° of north latitude, on the eastern slope of the Rocky Mountains, from which a Miocene flora yielding no truly tropical plant remains has been obtained. This flora, however, contains a large species of fan-palm (*Sabal Campbellii*), belonging to a genus which, if not strictly tropical, is at the present day confined on the American continent to latitudes some 13° or more south of the limit to which it reached on the flanks of the Rocky Mountains during the Miocene period. The Miocene flora of Northern Europe seems to indicate, however, a still greater difference in climate than this. The Cephalopoda and Reptilia of Europe during the Jurassic and Cretaceous periods do not, so far as their remains have yet been brought to light, appear to have been surpassed either in number or size in any other part of the world; nor does there seem to be anything in the vegetation of these, or of earlier periods, such as the Carboniferous, to lead to any conclusion different from that to which the animal remains would point. Nothing, however, in European latitudes from Miocene deposits has, so far as I am aware, indicated such a gigantic reptilian growth as that of the Crocodiles and Tortoises of the Sevalic hill-beds of India; and perhaps it is not contrary to what is already known to infer that the Miocene deposits do, to some extent, indicate a higher temperature in all latitudes than now prevails.

No. 7.—Very little can be said as to the cause suggested under this head; for although attempts have been made to arrive at some idea of the absolute temperature of space, the subject is too obscure for much reliance to be placed on the conclusions at which some physicists have arrived respecting it. It has been objected that no increase in the temperature of the space through which the Solar System was moving could occur, except from an approach of that system to some other stellar mass, sufficiently near to interfere with its integrity.

Such difficulties as may be presented, either by physics or geological evidence, to the 6th suggested cause, seem to apply, *toties quoties*, to the 7th also.

Reviewing now the whole subject as discussed in this paper, we find it bristling with difficulties in whatever direction we turn; and feelings of doubt and bewilderment arise which outweigh the force with which any one of the suggested causes might, at first sight, commend itself to our minds. Nor are the difficulties removed by taking refuge in the view that all, or some of the suggested causes have co-operated in producing the changes in climate which Geology scloses. Admitting always the influence of geographical conditions ıd currents as agents *materially modifying* climates however caused, has long appeared to me that, so far as the Glacial Period proper concerned, it is to the 6th suggested cause, a diminution in the ıat emitted by the Sun, that the probabilities incline. I am led to .is view, first, because it seems to me that, for the reasons men- oned in discussing the Geographical theory (No. 4), the cause of ıis period must have been a cosmical one; secondly, because, so far the evidence has yet been collected on the point, the cold of ıat period seems to have fallen upon the earth while its axis was in s present position; and thirdly, because nothing has yet been und to raise a doubt as to the glaciation of the northern and uthern hemispheres having been synchronous. As the Glacial eriod has passed away, the cause suggested under head No. 1, a crease in the planet's heat, cannot have been the cause of that eriod, even if its influence could be otherwise detected in changes climate. Of the remaining suggested causes besides No. 6, only os. 2 and 7 satisfy the three postulates which lead me to refer the lacial Period to No. 6; but No. 7 is obnoxious to the objection of ıe obscurity which surrounds it; and No. 2 has to contend with the ısufficiency of the limits within which astronomers confine the ıriation in the obliquity of the ecliptic to produce any material fect on climate, and also with the doubt as to what would be the fect of a large increase or decrease in that obliquity, were the stronomers' objections to its possibility removed.

How far this 6th suggested cause may have been the agency in roducing the climates of geological periods older than the Glacial, do not venture even to entertain an opinion, beyond this, that hatever was the cause giving rise to the Glacial Period proper, it more probable than otherwise that the same cause had a material, ıough perhaps not an exclusive share in influencing the climates of ırlier periods. It may indeed eventually prove to be the case that ıe close of the Geological record comprises the only part of the ırth's history during which any change in climate occurred, beyond hat Cause No. 4 was sufficient to produce, the normal temperature the earth's surface prior to the Pliocene Period having been igher than it now is.

V.—CONSIDERATIONS BEARING ON THEORIES OF THE FORMATION OF ROCK-BASINS.

By Hugh Miller, F.G.S., Assoc. R.S.M., H.M. Geological Survey.

THE arguments I endeavoured to outline in the June Number of the Geological Magazine have evidently been partly misunder- ood by at least one gentleman whose opinion is valuable, and I esire therefore to illustrate them somewhat further.

Although Mr. Bonney's criticism[1] seems to raise the question, hat is a tarn? mere titles are of little importance; and in order make his remarks relevant, it must be assumed that a rock-basin om half a mile to a mile long, and about 20 feet deep, comes

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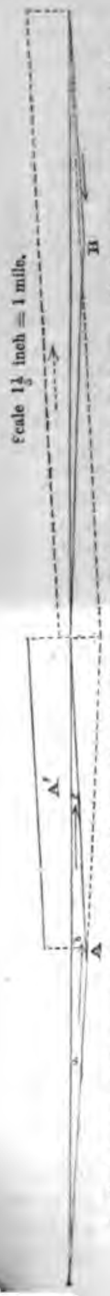
[1] Geol. Mag. for August, 1876, p. 377.



A. Rock-basin, with greatest depth at half its length. *b c*. Course of glacier and direction of force. A′. Inert segment of glacier. Dotted lines prolong A to twice its length and indicate position of glacier. B. Rock-basin (entered from right) on true scale for comparison. The slope opposed to the glacier is generally, as here, the longer one.

Note.—B and the proportional thickness of the glacier are taken from Mr. Clifton Ward's beautiful illustrations of the Cumberland lakes (viz. Wastwater), Quart. Journ. Geol. Soc. vol. xxxi. p. 166. Both are modified. A tarn half a mile long and 23 feet deep, if drawn as in A, would present to a glacier a slope of 1°.

under that designation. A lakelet of these dimensions, if admitted as the product of glacial erosion, would at least serve to remove glaciers from the category of "purely hypothetical causes"[1] in relation to larger lakes. But I venture to contend that it does more. It is not necessary at this time of day to urge that the admission commits one to the beginning of a perfectly graduating series of larger basins. Yet it seems to me that if glaciers be accredited with scooping powers at all, the initial stages of the process are just those most difficult for them to pass, and that, once surmounted to the extent of a good-sized tarn, they begin more fully to feel their power, and to work more easily and rapidly.

Supposing a basin half a mile long and 20 feet deep under a glacier or glacial sheet, and assuming the continuance of the favourable conditions which were able to originate it, there are now additional inducements to vigorous scooping; and these are probably twice as great as they were when the basin was half the size. A diagram will illustrate this. Entering the basin, it is clear that the first decrease of obstruction at *a* is followed by an increase of difficulty at *b*, from which point onward, gravity and friction have to be overcome by the accumulating pressure behind. The force necessarily exerted to impel a mass of ice equal to the area of this acclivity, and of the great thickness which glaciers have been proved to attain, against gravity and friction, when considered as additional to the first scooping incentive, cannot but be great, and is a progressively increasing quantity as the basin and the area of inert ice enlarge. Whether the basin shall deepen or lengthen more depends on varying circumstances; but, obviously, increase in the angle of slope tends in the same direction as its lengthening. When the mechanics of glaciers are better known, we may perhaps know in terms tolerably precise what the added force in given cases may be; for the mean time I think I am justified in holding that, even for a slope of one degree and a distance of 500 yards, it must be such as no theorist can afford to disregard.

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[1] Judd, GEOL. MAG. for January, 1876.

The tendency to proceed with a rock-basin once fairly begun plains a difficulty stated before by Mr. Bonney, and now reiterated.[1] [he great majority of Alpine valleys," he says, "show no tendency lake-basins, in places near, but above, the present lakes. . . . rely the glacier would have 'tried its prentice hand' now and en before, for example, excavating Como." Prof. Ramsay long o represented a vale-confined glacier as lacking opportunity to oop until it reached the plains. Of that I cannot judge; but by e view now set forth, when once fairly prenticed, the glacier ould be bound to respect its indentures, and make the best of the oove it had got into.

On rocky plateaux, such as the Norwegian "Fjeld," especially nong gneisso-schistose rocks, tarns of a size and depth probably mitted to be within the compass of the glacial, are often found nked together by shallow straits (generally constricted by the rder rock) into straggling sheets of water that might deserve the me of lake. These furnish an argument relevant to the present estion, and not, to my knowledge, before used. No valid objec- n can be urged against the admission of such combinations of rns to the glacial list that does not equally apply to the tarns ngly. But this admission can hardly come alone. The harder lges separating the tarns were, so to speak, accidents in the strata, eaking up a body of scooping force into detachments, and, if sent, a lake of one basin would exist, instead of the straggling ch compounded of several. The former are found to graduate into e latter, and cannot, I hold, be excluded without proof from the me category. I am far from disputing, however, that to include l lochs seemingly of these characters would be to commit mistakes.

On the grounds I have adduced, and upon others, it appears to me at no halting-place can logically be found by those who, with Sir narles Lyell, allow only "some mountain tarns"[2] to Prof. Ramsay's mand for lakes: that either a glacier is inadequate to hollow en a tarn, or that it can enlarge it to any reasonable proportions. it it is almost unnecessary to remark that, though *area* cannot (within oderate limits) be argued against the theory, proportion between pth and area might. A lake 50 miles long and 2000 feet deep ay be proportional in its gradients to a tarn half a mile long and) feet deep; and a glacier forced through the latter would—other ings being proportional—have one hundred times as much extra ducement to scoop as in the former; but could such a monstrosity ist as a half-mile tarn 2000 feet deep, it might be proved that the e, once in, must lie imprisoned and powerless.

Having thus imperfectly expressed some views on the point hich Mr. Bonney accuses me of "missing" in my letter, I may ss to the second part of his criticism. I can perhaps best rectify e injustice I did myself in naming "sharp synclinals," even in nnexion with a generalization, by illustrating my meaning further.

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[1] I am not versed in the proprieties of controversy, but it may be right to apologize Mr. Fisher for taking up this point, as it belongs more directly to him to answer.

[2] Student's Manual, 1871, p. 164.

Reference to the map of Sutherlandshire will show that in and near the district of Assynt, the larger lochs trend parallel with Loch Assynt itself, this parallelism being very marked, and the tendency to range in a transverse line—in other words to lie alongside one another—scarcely less so. Mr. Bonney has explained this arrangement on the subsidence theory, by supposing the line of depression to extend across parallel valleys, throwing them into boat-shaped hollows at opposite points.[1] Thus Lochs Fewn and Veyatie, L. Assynt, L. Glen Coul, and L. More, would fit into a depression which Loch Eriboll on the north, and the embayed side of Loch Broom on the south, might be supposed to terminate and confirm.

Between L. Assynt and the Fewn-Veyatie line comes the mountain Suilven, stretching its cathedral-like form in the same direction and across the imaginary depression. Canisp and Queenaig have similar relations to these or other lochs.

Now the stratigraphical evidence furnished by these mountains is such as is at once fatal to the theory,—plausible and seductive though it undoubtedly might seem. The nearly horizontal lines of stratification that traverse the naked sides of these mountains—lines that a straight edge would nearly coincide with—furnish a positive standard by which to test at least this theory, and comparing with them the probable contours of the neighbouring lochs, the curved lines of the latter are manifestly entirely at variance.[2]

It will scarcely be to digress to follow this theory a little further. There is another way in which the profile of neighbouring lines might be affected by the depression of valleys into lake troughs. Geologists of standing have traced ancient plains of marine denudation by the lines connecting mountain and hill summits. Surely recent depressions, when amounting to thousands of feet, might visibly affect the general outlines of hill ranges bordering lakes thus originated. Mr. Bonney finds an example of lakes arranged athwart valleys in Como and its neighbours. Do the elevated walls of the valleys in which Como, 2000 feet deep, and Maggiore, 2600 feet deep, are lodged, show a corresponding curve in their profile? The positive evidence of the soundings and of Mr. Bonney's observations tend, so far as I can judge, to support the subsidence theory in the case of the former; but the evidence cannot be complete until it is proved either that no such depression can be expected, or that it exists; and Mr. Bonney's theory especially requires this.

Passing now to the generalized argument I attempted to illustrate by the Cambrians of Assynt, I may repeat that, considering the multitudes of lakes and large tarns in the vicinity of the mountains displaying in section the features on which I have insisted, it may well be thought unfavourable to a theory ascribing these to flexure, ever equable, to find that rocks so old as the Cambrian, sub- d to vicissitudes which might multiply these effects a thousand- present lengthened sections of almost rectilinear uniformity. ring the *a priori* features of the question from a stratigraphical t of view, Mr. Judd asks,[1] "What reason can be adduced for ting that those great disturbing forces—which, during and sub- ently to the Oligocene and Miocene periods, have given rise to startling results in the contortion and even in the inversion of rocks of the Alps, but which at the same time have produced inconsiderable effects in the areas immediately surrounding —*must* have originated, in different parts of the great lines of age descending from those mountains, such inequalities of ment as could not fail to result in the formation of lake- is?" Fully recognizing these probabilities in the case of the , I can yet appeal to my friend Mr. Judd to reverse the argument, dmit the much greater *improbabilities* in the area I refer to.

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[1] Quart. Journ. Geol. Soc., vol. xxix. p. 394, and vol. xxx. p. 488.

[2] I may refer to my father's description of these mountains as "barred by the lines of nearly horizontal strata." On the Red Sandstone, etc., Deposits of Assynt; quoted in Murchison's Siluria, 3rd edit. p. 198. A fault crosses Suilven "East and West" (Murchison, Quart. Journ. Geol. Soc., 1858), but has no direct relation to the supposed line of depression. It is not contended that subsidence special to each of the lochs is here absolutely disproved.

concluding, it would well beseem me to apologize to older and geologists for venturing to differ from them. I hope, neverthe- that anything, however little, that tends to the elucidation of a ult question, will be received in the spirit in which it is offered. d looked, I confess, to Mr. Bonney to assume the intermediate ion which his views on the lakes of the Engadine and a recent ment in the Geological Society[2] rendered probable as his present but his letter fails to justify this hope.

only remains to add, that the assumption made at the beginning is communication—namely, that lakelets were at least occasion- scooped by glacier-ice—I hope soon to place beyond question.

-Additional Remarks upon Inversions of Carboniferous Strata in Somersetshire.

By Horace B. Woodward, F.G.S.,

Of the Geological Survey of England and Wales.

the Geological Magazine for April, 1871, I attempted to account for the mode of occurrence of the masses of Carbon- us Limestone that are found in the midst of the Coal-measure try at Luckington and Vobster in Somersetshire, and I then a picture of a faulted and inverted anticlinal to explain the omena. Mr. McMurtrie, who has more recently re-opened the ssion on the subject, and in a friendly manner assailed my y, again asserts that the Limestone masses "*must* in some have been folded over" from the Mendip range. He has very ly brought forward all the local facts that bear upon the ion, and has represented in diagram the mode by which he d account for the position of these isolated areas of Carbon- s Limestone.[3] No one is so familiar as is Mr. McMurtrie with letailed structure of the Somersetshire Coal-field, and I look forward with great interest to the facts which he is enabled from time to time to bring forward; nevertheless I may be pardoned for still differing from his general conclusions, inasmuch as the facts at present made known appear to me neither to upset my own theory, nor to establish that advocated by Mr. McMurtrie. Indeed it is only due to him to observe that he does not consider the question as finally settled, although he brings forward facts which seem to him to militate against the theory I ventured to propose.

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[1] Geol. Mag. for January, p. 11.

[2] See discussion on Mr. Clifton Ward's paper already referred to.

[3] Proc. Bath Nat. Hist. and Antiq. Field Club, 1876, vol. iii. p. 287.

Mr. McMurtrie remarks that "in the case of the Luckington area the workings of the Mackintosh pit have proved beyond doubt that the faults shown on the western end, the south side, and probably also on the north side of the Limestone, do not exist. Only one fault has been discovered there, and it runs in a north and south direction, crossing the eastern end of the patch." This, he adds, "has been well ascertained to be a downthrow west of 750 feet."

Although this evidence is highly important, it does not annihilate the theory that the Limestone itself is the relic of a mass dropped into the position by the agency of one main fault, and then the boundary of the Limestone and Coal-measures can only be represented as an abrupt and faulted one.

In regard to the masses of Limestone at Vobster, there is no direct evidence either for or against the theory which requires faults.

But even the mining records, although they furnish important facts, are in themselves scarcely adequate to explain the great movements in the strata, for their evidence is after all somewhat limited and restricted. And in all efforts to solve the mystery, it is very necessary to bear in mind what are the facts and what the inferences, and in Mr. McMurtrie's, as well as in my own diagram-sections, the imagination has necessarily been brought into scientific use to complete the picture.

Since my paper was published the re-survey of the Lower Secondary and Palæozoic rocks of the Mendip country has been completed, and the new edition of Sheet 19 has been published, while I have reviewed the subject again with the benefit of all the facts thus brought together, collecting some important evidence which I had not fully weighed before, and which seems to me to throw a side-light, as it were, upon the faulted-anticlinal theory.

In so disturbed a tract of ground as this portion of the Somersetshire Coal-field, one must interpret the grand earth-movements in a large way, for the numberless contortions and twistings in the Coal-measures themselves are but the exaggerated representatives of great folds in the older and more stony strata. The Lower Coal-measures, for the most part easily squeezed up and crumpled, cannot in themselves explain these phenomena, and therefore a study of the folds that are readily to be traced out in the Carboniferous Limestone and in the Old Red Sandstone is very necessary before we attempt to picture the amount of disturbance in the district. This evidence seems to me the more important, because, as Mr. McMurtrie on his theory admits, "we cannot pretend to trace in detail the process of elevation, folding over, and settling down, which must then have taken place. And we cannot yet explain, where so much has been denuded, why these masses of Limestone remain."

As I have elsewhere remarked, in considering this somewhat difficult subject, it must be borne in mind that the structure of the Mendip Hills is not that of one simple anticlinal fold dipping to the north-east and south-west, and trending north-west and south-east; but that the structure displayed comprises a number of folds, which trend in an easterly and westerly direction, and which are products of that line of upheaval, which, only when looked at in a large way, can be termed the "Mendip Anticlinal."[1]

Thus immediately north of Shepton Mallet, and in a line between Cheylinch and Bowlish, there is evidence of an anticlinal; and it is probable that this is the continuation of one noticed north of Leighton, which is, however, displaced by a fault.

A second anticlinal extends from near Frome, by Little Elm and Downhead, to Masberry Castle, and is continued through Lyat Hill.

A third anticlinal is met with at Pen Hill, and thence continues westwards to the Ebber Rocks, and in a north-easterly direction to Lechmere Water, near Emborrow. The beds are much faulted; at Ebber and Pen Hill House, the Old Red Sandstone is brought against the Carboniferous Limestone, and at Emborrow it comes in contact with the Millstone Grit. These faults are of great magnitude, the amount of displacement at the last-named locality being probably at least 3,000 feet.

A fourth anticlinal runs from North Hill westwards through Stoke Warren, and probably accounts for the trace of Old Red Sandstone which my colleague, Mr. Blake, considered to be faulted against the Carboniferous Limestone about a mile south-east of Cheddar. Here again is another fault of great magnitude.

A fifth anticlinal, that of Black Down, is continued through Bleadon Hill to the Steep Holme. This islet, as is well known, exhibits an inverted anticlinal of Carboniferous Limestone, the strata being bent over in a northerly direction; and this feature is repeated at Dolberry.

So that if we constructed a longitudinal section through the Mendip Hills, we should find the structure to consist of a number of anticlinals, locally faulted and inverted. And it is the prolongation of these known disturbances into the Coal-measures that must help to account for the great dislocations and contortions that affect them. We can scarcely expect to trace their continuation with exactness in these newer and more easily contorted strata, and in the Nettlebridge Valley the amount of confusion which the Coal-measures present is so great, that Mr. McMurtrie remarks it would baffle description. The Radstock slide-fault is likewise a remarkable instance of local disturbance. Nor must the evidence of another considerable fault be neglected, and this is the one which runs from Beckington to near Mells, and whose natural continuation would be to Vobster. Along this line of fault a trace of Old Red Sandstone is brought to the surface north of Frome, as first represented by Lonsdale.[2]

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[1] See Memoir on the Geology of East Somerset and the Bristol Coal Fields, p. 196.

[2] Trans. Geol. Soc. 2nd ser. vol. iii. plate 32.

The influence that these anticlinal disturbances may have in complicating the probable Coal-field on the south of the Mendips is a point that should not be neglected.

Without wishing to ride my own theory too hard, I cannot help thinking that the subject must be looked at in this large way, and although I may have to modify the direction or upthrow of the faults whose help I have invoked in my necessarily diagrammatic sections, yet the explanation itself seems to accord better with the ascertained disturbances of the area than one which conjectures that they have in some way been folded over from the Downhead anticlinal of the Mendip range. The physical structure is entirely opposed to this folding over, as I showed in my former paper.[1]

That the structure might have assumed such a form as that represented by your Indian correspondent[2] is by no means impossible, but we lack the positive evidence. The masses of Limestone would then be the result of fragments dislodged from the denuded escarpment, as Mr. Brice has conjectured; yet when we come to draw out this supposed structure on a true scale, more difficulties arise, so it seems to me, than on the theory I have proposed, even if we take into consideration the evidence of partial inversion of the Millstone Grit, and perhaps also of the Old Red Sandstone at East End.

The existence of such Limestone masses in the midst of an area of Coal-measures is not without its parallel elsewhere in England. There are patches of Limestone situated in the Coal-tract of Clapton-in-Gordano, but I have never visited this area: and although they have been traced out on the map of the Geological Survey, their occurrence has not, so far as I am aware, been explained. In Devonshire, too, in the midst of the Culm-measures, there are some very puzzling masses of Devonian Limestone, which have been alluded to as indicating unconformability; but here there are numerous faults, and the difficulty lies in tracing across country those faults actually determined in the Culm-measures, owing to the absence of any marked beds in this series.

Were a geologist, indeed, whose mind was filled with Glacial theories, to come directly from Norfolk or Lincolnshire, having been impressed with the really wonderful transported mass of Chalk met with in the one county, or of Inferior Oolite and Marlstone that are occasionally met with in the other, he might be led to suggest a similar explanation to account for the isolated masses of Limestone that occur on the Coal-measures of Somersetshire. But, after all, the question is not which agent is most capable of producing the phenomena, but which agent capable of the work is most in accordance with facts; and I still think a word may be said in favour of the faulted-anticlinal theory. At the same time I fear the verdict must yet remain one of *not proven*.

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[1] No traces of Millstone Grit *in situ* have been traced either at Luckington or Vobster, but Mr. McMurtrie has noticed blocks of it in a field to the north of Upper Vobster. In my diagram-section I have introduced the Millstone Grit here. The occurrence of stray blocks, however, is but uncertain evidence; similar blocks occur on the surface of the ground near East Harptree.

[2] See Geol. Mag. Dec. II. Vol. II. p. 567.

VI.—Dr. H. Landor on Ground-Ice as a Carrier of Stones and Débris.

Communicated by James Geikie, F.R.S., L. & E., F.G.S.

SOME years ago (November 15th, 1869) Dr. Henry Landor, Superintendent of the London Asylum, Ontario, communicated to the Entomological Society of Canada some observations on the action of Ground-ice, which seem to be of sufficient importance to be reproduced in the pages of this Magazine. The Entomological Society does not appear to publish its transactions, otherwise a simple reference might have sufficed. The account of Dr. Landor's observations here given is extracted from the local *Free Press*, of London, Ont.

"Ground-ice is that ice which is formed at the bottom of running streams, and which adheres to the bottom for a greater or less length of time, and which is often seen floating down all the rivers of Canada in small pieces after a severe night's frost and a sunny morning. There have been many theories given by men of science to account for the formation of ice on the bottom of rivers running rapidly. It has engaged the attention of men of such eminence as Arago, but I think no theory has been given which will account for all the phenomena. The facts are few and simple. When the thermometer falls to within 10° of Fahrenheit, ground-ice begins to form, but it is not, at that temperature, long adherent to the bottom. As soon as the sun rises, it rises and floats away in great abundance of small light porous portions of ice, covering for the most part the centre of the stream. But when the thermometer is at zero, the ice adheres to the bottom, and it is most apparent where the stream is the most rapid. It is then most abundant where there is no surface-ice. There is none where the surface is frozen over. Depth of the stream, at any rate to six feet, if it is rapid also, does not prevent the formation of ground-ice; for it is seen abundantly on the bottom of the St. Lawrence rapids, and at the Tubular Bridge, Montreal, which affords a favourable point for observation, before the surface is frozen over. As the frost continues, the ice at the bottom thickens. It is tubular, or honey-combed, in the direction of the current, and the water pours through the tubes. It is rarely solid, but it is so after long continuance of hard frost. It adheres to the stones at the bottom, or to the ground itself, and it remains anchored until its power of flotation enables it to rise to the surface, and carry its anchor with it. It comes to the surface with stones attached to it. These stones, of course, bear a proportion to the mass of ice. When the mass is small, the stones it raises are small, and are only pebbles; but when the mass is large—and it often is a large mass that rises to the surface—it brings adherent to it large stones, deserving to be called small boulders. The mass floats away down the stream to the next part of the river that is frozen over at the surface. There it becomes frozen in with the mass of surface-ice, and in a very few hours loses its porous condition altogether. It remains there until the break-up of the winter, and it is then impossible to say whether the stones in the ice were thrown on the surface and then frozen in, or whether they were brought from the bottom by ground-ice. As soon as the tubular character of the ice is lost, the power of discriminating the origin of the stone is lost also. I have seen in the small rivers that form the Thames a vast number of pebbles and stones, as big as a foot diameter, carried away by ground-ice. Some years since I watched the rapid portion of the rivers daily, and frequently saw the ice rise with stones attached. A warm sun, after a zero frost, about 10 A.M., is the proper time and the proper condition for seeing the rise of the ice; and some patience is necessary in waiting, for what will not rise one day may rise the next, and the colder the night, the nearer mid-day, when the sun has most power, the phenomenon occurs. These blocks, with adhering stones, travel down the river in the spring, but how far they go must depend on their power to keep their mass unbroken. When I was in London, I thought it would be impossible for them to reach the lakes before being broken up, at weirs, or by knocking against each other. But whilst here—Amherstburg—last winter, when the ice broke up twice in the Detroit river, I saw masses of ice with boulders such as I named, and pebbles in vast quantities adherent, float past this asylum, which, I have no doubt, came from the ground-ice formed in some or other of the rivers that empty into Lake Huron or Lake St. Clair.

"Before I consider the results that follow from this subject, I will say a few words on the difficulties of the formation of ground-ice. The first that presents itself is the congelation of water at the bottom, when we all know that the peculiarity of water, when at rest, is, that it cannot freeze at the bottom until the whole mass is frozen from the surface downwards. It is needless to state to you the nature of the changes that take place in water when it alters its temperature to the freezing-point. Knowing them, it is hard to conceive how the first act of congelation takes place at the bottom, without the ice at once rising to the surface. It seems clear that the first condition in the formation of ground-ice must be, that the temperature of the stones at the bottom falls below freezing-point; but it is not clear why the temperature should so fall, covered as they are by water that is above the temperature of freezing-point. I have never seen the water below 32° when taken out of the river; and it is clear that if it were below that point, as soon as it is taken into a vessel it ought to become flaky with atoms of ice the moment it is at rest in that vessel. Whilst running rapidly, water may not congeal, even if slightly below 32°, but at rest it should do so constantly. Moreover, if the water is below 32°, which I have never observed, the whole mass of the river must be below 32°, for it is impossible to suppose that it becomes so just as it begins to run over the shallows, and ceases to be so when it reaches the still depths again; for it must be above 32° in the deep parts of the river, or else it would become ice; and it should be *colder* in the depths, because it is in less agitation than in the shallows. Motion is warmth in all bodies, and it is the same in water as in solids. Motion is warmth, and therefore there ought to be more warmth in the rapids than in the *still water*; all which considerations make the subject of ground-ice more difficult of comprehension. If, then, this is not so, as it seems to me impossible it should be, the reason why ground-ice forms is not because the water is all below 32°, and the bottom of the river colder still to make the ice adhere to it. I never tried the temperature of the bottom, for it is a problem too difficult for practical solution (without much care and expensive apparatus) to find the temperature of the stones while they are *in situ*. No doubt there is wanting a well-conducted series of observations of the temperature of the river and bottom, night and day, which it has never been in my power to make. It seems to me, from theory, that the stones must be below 32°, and it is to me utterly impossible to say how they become so in such a situation as they are. Any scientific work on temperatures will give various theories on this subject, so that I need not take up time in alluding to them. None of them, to my mind, fulfil all conditions; and, if it were only for this object, further observations are desirable.

"I will pass on to the results of ground-ice, and first on the subject of stones and boulders. If on one river so many stones as I have seen go down the Thames are carried, some of them as far as Lake Erie, what must be the amount on all the rivers emptying into the lakes? The stones are for the most part portions of those contained in the glacial drift, which covers so large a part of Canada, and they have already been brought to the beds of the rivers from distant sources ages ago, in the glacial period. This removal by ground-ice is, therefore, their second journey. Now, suppose that Lake Erie were laid dry, its surface would present the appearance of a level plain, covered more or less with pebbles and boulders of the same kind of stones as those contained in the glacial drift on the rest of Canada. Would not any geologist, unacquainted with the phenomena of ground-ice, say that the stone-covered plain of Erie was the result of glacial times also? But how wrong he would be. For it would owe its boulders and pebbles to the action of causes ages subsequent to the glacial period. So far from the pebbly drifts being contemporaneous with the drift of the present dry land of Canada, it would belong to distant geological epochs, widely apart in time, and wider still in climate. How difficult it is in geology to say what deposits are contemporaneous, or what separated by ages. In this case the fauna might enable the geologist to discriminate if any should be deposited. All the stones he would see might, and most probably would have been brought by ground-ice. Suppose that one river only takes 10 stones a winter into Lake Erie, a ridiculously low estimate. There are above 80 rivers debouching into Lake Erie, not counting those that come laden with stones by means of the Detroit river, probably equalling in results all the 80 put together. That would give 1,600 stones in one winter. Now, according to Lyell, 30,000 years have passed since Erie and Ontario bore their present form, which in that time gives 48 million of stones, and this is a most moderate estimate of the result in both time and quantity. I give it to show that the effect of ground-ice during incalculable ages must be important, and the cause of considerable geological changes, distributed over large areas, and of consequence in the estimate of geological conditions. Nor is the effect of ground-ice confined to Canada. The rivers that flow into the Northern Mississippi carry the same conditions into the south, as far as the ice floats undissolved. But if this subject has a bearing on geology, it has a far greater effect on the distribution of species, both of plants and small living creatures, fresh-water shells and insects especially. With the stones, portions of earth are very frequently carried by the ice, and every mass of earth contains seeds of land or water plants, which are borne down the rivers and distributed wherever the mass of ice breaks up. Some of these ice-bearing boulders and earths are driven on to the land at the sides of the rivers or lakes, and there dissolve, and there the seeds germinate and the insects flourish, perhaps planting species where they were before unknown. Now consider the result of this operation on rivers like the Mississippi, or the Saskatchewan, or the Mackenzie. From a central area, the Mississippi and the Mackenzie distribute species in opposite directions, some of which may be new to the countries they rest in, and may be able to endure the difference of climate. The Saskatchewan distributes west to east, from the Rocky Mountains to Hudson's Bay. As it is most probable that the Rocky Mountains emerged from the ocean before the plains to the east or west of them, it is possible that, as vegetation and insect life began in these mountains, both were mainly distributed over the continent, as it gradually rose above the waters, by this very agency. At any rate, if the climate was as it now is, this agency must have borne a large share in the distribution of life over the land wherever the streams from the mountains flowed. But these phenomena are not confined to North America. The rivers of Siberia do the same thing; so do the rivers of Northern Europe. Therefore the effect of ground-ice on the distribution of species over limited areas does not deserve to be overlooked. I think these are the chief facts that occur to me on this subject. I am not acquainted with any other observations on this matter. It is not even alluded to in Lyell 'On the Distribution of Species,' nor does Darwin notice it. I am desirous that it should be further examined, and I send you this paper to induce some of your members to take the subject up, and carry on their observations in a combined manner, with proper means, which can be more readily provided by a society than by an individual. I do not pretend to anything more than a very limited amount of observation, and my speculations may or may not be confirmed by better and more scientific observers. I leave the matter in your hands. I think this paper, on a new subject, is deserving of publication, if only to cause others to make more efficient examination."

"*Note.*—The Thames is every year becoming more unfit for observations on ground-ice. Less water comes down it, especially the north branch, so that the shallows will hardly float ice that can carry a boulder. I saw more ground-ice in the four winters from 1860 to 1864 than in the last six years. The Grand river I should think more suitable for observation."

Dr. Landor writes me this summer concerning some further observations made by him as follows: "There is another fact n my personal knowledge that makes additional difficulty :counting for the formation of ground-ice. The main pipe supplies the pumping engine of the Detroit Waterworks vo feet in diameter. and is 20 feet under the surface of iver, at the distance of 100 feet from the shore. In the :r of 1868 ground-ice adhered to the wire covering over the h of the pipe, placed to prevent the entrance of fish into ipe. The whole wire was so covered with ice as to prevent the ı of the pumps by impeding the entrance of water. It is very ult to account for the ice at that depth, while the water flowed r above and below the pipe. The cold could not be transmitted the shore along the iron pipe, for the pipe was not covered ice. It seems that the condition of rapid flow through narrow nstricted places, like the interstices between stones, or the wire-l, are necessary to produce congelation; but why it should be ıced in such difficult circumstances I am not able to say. The oration of Detroit had the matter considered by those they ;ht competent to give an opinion, without any result, but that ıving men to break the ice off the pipe-mouth daily, or when-the temperature was low. The circumstances of this pipe are difficult to account for than the ordinary ground-ice at the moderate depths, because 20 feet of clear water and 100 feet the shore are the difficult parts of the problem."

:re, then, is a riddle for some of our physicists to solve; for it be admitted that the mode of formation of ground-ice is still, y the least, imperfectly understood.—J.G.

NOTICES OF MEMOIRS.

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MONTHLY NOTICES OF PAPERS AND PROCEEDINGS OF THE ROYAL ·CIETY OF TASMANIA FOR MARCH, APRIL, AND MAY, 1875. 8vo. ›. 29 and viii. (Hobart Town.)

LY one paper calls for attention on our part, viz. that by the Rev. J. E. Tenison Woods, "On some Tertiary Fossils from .e Cape" (pp. 13-26). The beds from which the fossils were ined are correlated with portions of two horizons in the Cape ay Series, Victoria—an Upper or Polyzoal Limestone, with *ıipatagus Forbesii*, Woods and Duncan, and *Cellepora Gambier-*', Busk; and a Lower, or Brown Clays and Sandstones, dis-nished by the presence of *Pecten laticostatus*, Quoy. From the nanian representatives of these beds, twenty-seven species of lusca are enumerated, of which eleven are new to science. The rzoa are not numerous, being chiefly the remains of the charac-.tic *Cellepora Gambierensis*, Busk. The Echinodermata are ined to the almost equally characteristic *Hemipatagus Forbesii;* lst of the Corals three of the forms belong to already-described ies, and two others are probably new. Four species of Forami-ra are mentioned. The presence of a portion of the great South tralian Tertiary formation leads Mr. Woods to the conclusion Tasmania has shared in the general upheaval of the south coast of Australia. The occurrence of these beds in a longitude east of similar ones in Australia, "proves one more link to the union of these beds with the great Tertiary formation of New Zealand." In the nomenclature of Professor P. Martin Duncan the Table Cape beds will be Lower Cainozoic. Mr. Woods describes the new species of Mollusca in detail. R. E., JUN.

II.—ON A NEW CRINOID FROM THE CRETACEOUS FORMATION OF THE WEST. By GEORGE BIRD GRINNELL. American Journal of Science and Arts, No. 67, vol. xii. (July, 1876), pp. 81–3, pl. 4.

UNTIL the discovery of the unique fossil, described in the above paper, by Professor O. C. Marsh, Crinoids from the American Cretaceous were unknown. The new form, to which the name of *Uintacrinus socialis* has been given, belongs to the *Astylidæ*, or free Crinoids, and is allied to the genus *Marsupites*, Miller. It differs from the latter in the form and arrangement of its plates, and in having apparently ten arms; it may be the type of a new group. The individuals are found associated together in considerable numbers, hence the specific name. *U. socialis* was first discovered by Professor Marsh in the Cretaceous of the Uinta Mountains, associated with the scales of a *Beryx* and *Ostrea conjesta*, Conrad. Specimens have since been discovered in the Kansas Cretaceous beds, associated with Odontornithes, Pterodactyles, and Mosasauroid reptiles. Mr. Grinnell gives a detailed specific description.

R. E., JUN.

III.—COTTESWOLD NATURALISTS' FIELD CLUB.

DURING the past two years the Members of this Club have been as active as ever, and the results of their researches—almost entirely geological and archæological—form a large and well-illustrated series of papers. The Addresses of the President, Sir William Guise, contain an epitome of the work done, and the records of those pleasant field meetings for which this Club has always been celebrated.

Excursions have been made to Newent, Bath, Radstock, Farringdon in Berkshire, Chepstow, Symonds Yat (Ross and Monmouth), Pendock, Portskewet, Caldicot Castle, and Caerwent. And it is needless to say that under the able guidance of Dr. Wright, the Rev. W. S. Symonds, Messrs. Etheridge, C. Moore, Lucy, McMurtrie, and others, the many points of geological interest met with on these several excursions have not been neglected.

The printed papers include one on a Bed of Fuller's Earth at Whiteshill, near Stroud; and another on the Angular Gravel of the Cotteswolds, by Mr. Witchell. This Angular Gravel, which occurs on the slopes of the Oolitic escarpments, was at one time considered to be the remains of sea-beaches—a view now happily abandoned. It consists of Oolitic detritus, and is evidently the result of subaerial denudation. Mr. Witchell considers that the formation probably commenced before the river-gravel was laid down; and that perhaps the period to be assigned to its commencement is that of the recurrent period of cold, during the latter part of the Glacial epoch. And it continued, in his opinion, to be formed while the slopes remained exposed, and ceased only as vegetable matter began to cover up the surface.

The Rev. W. S. Symonds contributes some notes on the Geology and Archæology of Malvern, having reference more especially to the Permian and Triassic rocks. He observes that the pebble-beds towards the base of the 'water-stones' contain pebbles of a quartz-rock, exactly similar to those of the famous Budleigh Salterton Beds.

Other papers there are on the Ancient Wall of Gloucester, on Sherston Magna, on the Ancient Camps of Gloucestershire, and on Offa's Dyke, but these do not come within the province of the geologist. H. B. W.

REVIEWS.

I.—FIELD GEOLOGY. By W. HENRY PENNING, F.G.S. WITH A SECTION ON PALÆONTOLOGY. By A. J. JUKES-BROWNE, B.A., F.G.S. 8vo. pp. 227. (London: Baillière, Tindall, & Cox.)

AMONG the many species of Geologists whom the progress of Science has developed, the Field Geologist is perhaps the most peculiar in his life history and method of work. There is, it is true, a kind of gradation between all classes of workers, but the man who devotes his time to the mapping out of various strata exposed at the surface has very generally been enveloped in a sort of mystery. Many of those whose opportunities of going into the field are confined to a month or six weeks in the year are at a loss to understand the evidence by which the geological lines are drawn upon our maps with such apparent precision, and if in their examination of fresh cuttings they find a boundary-line has been drawn five or ten chains too far in one direction, or a small fault has been altogether omitted in another, they are confirmed in their opinion that mapping is to a great extent conjecture, and that the lines depend very much upon the fertility of the imagination. But the Field Geologist is no more a sudden and special creation than the Lithologist, the Mineralogist, or the Palæontologist. In each branch of inquiry development can only result from experience, and although many Geologists possess a wide range of knowledge that embraces every branch of the science, the Field Geologist is more generally restricted to his special work. And yet, with this restriction, they may include among their number some of the most eminent of Geologists. William Smith, Conybeare, Sedgwick, Murchison, and De la Beche,—each gained his reputation from hard work in the field.

But the work of the Field Geologist of the past is to some extent different to that of the present generation. The honoured leaders, so far as our country is concerned, have drawn in all the main outlines, and the work that they left to be done is but the filling in of the details. The lines sketched in by William Smith, sometimes from the top of a coach, were at the time sufficiently accurate for the scale of map he used, and considering the amount of country he personally examined, his work could not be surpassed by any one man. Even the early maps of De la Beche, grand works as they will always remain, necessarily lack the minute precision that the labour of many lives alone could give it; for the detailed mapping of the whole of Devon and Cornwall would probably occupy more than the entire lifetime of the most expert Geologist.

The old work, carried on for the most part by noting carefully all the junctions between two formations observed in travelling along the roads, and then carrying on the boundary-line according to contour or the hill-shading on the map, must now be supplemented by careful attention to minor features, if any advance is to be made in Field Geology. And it is only by such careful attention to detail that the structure of a country can be rightly understood, or a correct interpretation be made of the varied forces which have combined to sculpture its scenery. To carry on a minute survey of a country one must be prepared to stay many weeks or months at one locality, and in an entirely fresh district it will take at least a month of hard work to get well acquainted with the character and mode of occurrence of the rocks, before any regular mapping is commenced. How to set to work is to the novice a matter of considerable difficulty. The advantages enjoyed by those who serve on H. M. Geological Survey are great, inasmuch as the beginner can start at once under the guidance of some trained man. But those who would wish to start independently, and work out the geology of a district for themselves, have had no guide and philosopher to direct their footsteps, if we except some scattered notes in geological text-books, and the brief hints given by Jukes in his "Manual," and by Clifton Ward in his "Elementary Geology." Mr. Penning, an experienced Government Geologist, now steps forward and presents us with a concise handbook of Field Geology, to which his colleague, Mr. Jukes-Browne, has contributed some notes about the use and abuse of fossils. The work commences with a description of maps, and of the instruments necessary for geological work. The author then takes us out into the field into a country of Reading Beds, Chalk, Greensand, Gault, and Alluvial deposits, where perhaps the simplest kind of field-work can be met with. He explains very clearly the character of the work and the method of proceeding, and so far we feel we could get on very comfortably. In a subsequent chapter he takes us on a survey of the older rocks, the Trias, Permian, and Carboniferous rocks, and a felstone dyke, and the work again seems so clear and straightforward that we regret he does not take us a step further, and illustrate the mapping of a more complicated district where the rocks are greatly contorted, where the stratification is obscured by cleavage, and where there are striking instances of unconformability. The discrimination between faults and unconformabilities, and, in the case of eruptive rocks, the determination of those which are intrusive and those which are interbedded and conformable, require more notice than the author has given to them, as likewise do the dications of metamorphism; while the remarks quoted from Lyell). 120) can scarcely be said to represent the present state of our nowledge of metamorphic rocks.

The advice furnished on the construction of Horizontal Sections the use of the Aneroid, the Level, and the Theodolite, is very od, and the author rightly points out the necessity of obtaining a ue outline of the ground.

In very complicated districts Jukes's plan of inserting only the cts observed might be more generally adopted with advantage; d in all cases it is well to distinguish between actual sections and rely diagrammatic sections.

The remarks on Lithology and the tables for the determination of cks and minerals cannot fail to be useful.

Mr. Jukes-Browne gives a good account of the character and mode occurrence of fossil remains, with hints for collecting. The cessity, unfortunately too little attended to, of keeping accurate cords of stratum and locality is insisted upon. The practice also only keeping "typical specimens" is justly condemned, since, the writer remarks, "it tends to confirm the old superstition at species are definite abstractions, and to draw hard and fast es between cognate forms which are unnatural and non-existent reality."

The value of palæontological evidence is fairly treated, and the portance of their stratigraphical position being well established fore they are used as a clue to the identification of isolated deposits, likewise noted.

Mr. Penning has carefully compiled a list of characteristic fossils ranged alphabetically under each zoological order, so that if a ecies of fossil be known, the approximate (if not exact) geological sition of the rock to which it belongs can readily be determined.

We have said little about the method of drawing boundary-lines, we can confidently recommend the Guide before us. Those who rt with this book as a companion will soon be able to grasp the ethod of tracking the divisional line between two formations, but would be difficult to draw hard and fast rules, inasmuch as the aracter of the work and the evidence to be relied on varies much ith the different rocks. The irregular cappings of Drift gravels d Boulder-clay, the tolerably regular escarpments of the Secondary d Upper Palæozoic rocks, and the often confused state of the wer Palæozoic rocks, involve distinct kinds of evidence and trains thought.

But in all cases such evidence as that furnished by springs, soils, d the form of the ground, must receive its due attention; and in cases the results of ancient and modern landslips must not be glected.

That the work might be amplified with advantage the author mself admits, and in the event of a second edition we should like see a chapter intended for those who set to work in an entirely esh country where little or no order in the succession of rocks has en made out.

II.—PRACTICAL GUIDE TO THE ISLE OF WIGHT. BY HENRY IRWIN JENKINSON. (E. Stanford, 1876.)

THE first important work descriptive of the beauties of this interesting island, that of Sir Henry Englefield, contained the valuable letters of Thomas Webster, which may be regarded as having laid the foundation of British Tertiary Geology. And, since the appearance of that work, every successive guide-book has very properly aimed at giving some account of the geological structure of a district, concerning which Mr. Hopkins very justly remarked that, "it might have been cut out by Nature for a geological model illustrative of the phenomena of stratification."

The latest-published guide to the island, which now lies before us, presents so many excellent features—as regards convenience of arrangement and general accuracy—that we greatly regret to be obliged to speak in terms of unqualified condemnation concerning its geological section.

The ten pages devoted to a summary of the characters of the several geological formations exposed in the island contain more than the average number of blunders usually committed by innocent compilers; and no attempt seems to have been made to bring the information up to date by a reference to the latest-published accounts of researches carried on in the district. All this is, however, venial compared with the offence committed by the author in the last seven pages of his chapter on Geology. Like an individual calling himself "Parallax," who fancies that all astronomers are labouring under a delusion, and that the earth is not spherical, but flat, Mr. Jenkinson insists on laying before his readers a number of arguments which prove nothing but his total incompetence to deal with scientific questions at all. One quotation from the statement of what he is pleased to call his "new theory," and which, it seems, has been already published in several guide-books, will more than suffice for the readers of this MAGAZINE.

Speaking of the highly-inclined strata of the Isle of Wight, he says: "After many attempts to settle the matter distinctly to my own mind, it gradually appeared clear to me that the contortions and various angles of the layers of flint in the chalk, may be accounted for by the deposits on the irregular surface of an ocean-bed; and that the vertical strata of the Lower Tertiaries are merely parts of an arch or curve caused by the strata having been deposited on the sides of the chalk downs, the curves gradually disappearing and resolving themselves into horizontal lines, in one direction on the summits of the downs, and in the other at a little distance from their base." Mr. Jenkinson has "satisfied *himself*" that geologists are altogether in error in supposing that movements have taken place in stratified rocks subsequently to their deposition.

We would earnestly recommend the author, before making any further exposure of "his theory" or himself in guide-books, to carefully read some manual of Geology—a very simple and elementary one, like Professor Geikie's excellent little Primer, will be best adapted for the purpose—and to make himself acquainted with what are the actual conclusions of geologists on these subjects, and the grounds on which they are based. Were it not, perhaps, asking too much of the authors of guide-books to request them to examine for themselves the objects which they undertake to describe, we would suggest, in the present case, a visit to Whitecliff or Alum Bay, where the pebbles which occur in numerous bands will be found to have their longer axes vertical.

Neither astronomers nor geologists can of course object to "Parallax" and Mr. Jenkinson exhibiting their mental eccentricity in volumes which are correctly labelled—volumes which we are free to purchase or reject as we please—but we must strongly protest against such nonsense being foisted upon us under the innocent disguise of a "guide-book."

III.—Leonhard und Geinitz's Neues Jahrbuch für Mineralogie, Geologie und Palæontologie, 1874–75.

AS usual, and for many years past, the current literature of Geology and associated sciences is well represented in this valuable periodical; and the researches of our fellow-workers in Germany and elsewhere continue to enrich its pages with new facts and theories.

Jahrgang 1874, Hefte 1–9.—Besides the numerous communications addressed to the Editors by geologists and mineralogists from every side, which often constitute memoirs in themselves, such as the letter on the schillerquarz of Oberstein, etc., by Dr. H. Laspeyres,—G. vom Rath's letters on foresite from the granite-veins of Elba, and wollastonite in the phonolite of the Breisgau.—A. Knop's on the segregation of silica and formation of oolite,—E. Weiss's on the Mansfeld weissliegende,—O. Fraas's on fossils from Palestine, etc., we find—

In Palæontology:—V. von Möller on *Volborthia*, a new genus of fossil Brachiopods (pl. vii. part); and O. Feistmantel on the Carboniferous *Equiseta*:—*Equisetum Schuetzeanum*, O. F.; *Eq. infundibuliforme*, Brongn.; *Eq. priscum*, Geinitz; *Eq. giganteum* (L. & H.); *Eq. brevidens*, Schimper; *Eq. rugosum*, Schimp.; *Eq. dubium*, Brongn.; *Eq. Socolowski*, Eichw.; *Eq. radiatum* (Sternb.); pl. vi.

In Geology:—A. E. Törnebohm on the gneissic district of Sweden (pl. iv.); F. Diffenbach on the Earthquakes (141) and Volcanic eruptions (Kilauea, Merapi, Vesuvius, Maunaloa, and St. Vincent) of 1872; F. Maurer on some fossiliferous Devonian rocks between Giessen and Friedberg (pl. vii. part); E. Cohen's geological and petrographical notes on South Africa (pl. viii.): I. Bibliography: II. Vicinity of Cape Town; 1. the Granite, 2. the Diabase, 3. the Schists, *a*, the Lion's Rump; *b*, Sea Point; *c*, Platte Klip, 4. the Sandstone; Carl Naumann on the Hohburg porphyry hills in Saxony—a woodcut and map (pl. v.) (the last work of the author, and scarcely finished); Alb. Heim on the Slickensides in the porphyry hills on Hohburg; Th. Wolf's geological notes on Ecuador: 1. The occurrence of quartz-andesite in the highland of Quito; 2. Geological Sketch of the Province of Guayaquil; 3. A mud-volcano on the west coast of Ecuador; and H. B. Geinitz's Obituary of C. F. Naumann.

In Mineralogy and Petrology:—C. Klein's Mineralogical notes: the optical properties of the Sulzbach epidote (pl. i.); Burkart on the iron-meteorite of Poblazon, Mexico (pl. ii.); Burkart on telluric and bismuth minerals in the U.S. of America; Westphal on a porphyry vein, with loose orthoclase crystals, in the Elbe valley district; H. Möhl on the mineralogical constitution, classification, and distribution of the phonolites; A. Weisbach on roselite; Websky on some remarkable specimens of quartz from Neuhaus, Oberstein, Baveno, and Traversella (pl. iii.);

H. Schroeder's researches on the atomic-constitution of some minerals: 1. Lime-garnet and magnesia-garnet; 2. Spinelle and gahnite; A. Streng on some minerals in the cavities of vesicular basalts (pl. ix.): 1. Phillipsite; 2. Apophyllite; 3. Mesolite; 4. Faujasite, and pseudomorphs of palagonite after faujasite; 5. Gismondine; Burkart on some new Mexican localities for minerals; A. Frenzel's mineralogical notes; H. Möhl's mineralogical notes (pl. x.); G. vom Rath's Obituary notice of Dr. Friedrich Hessenberg, with extracts from his mineralogical notes (woodcuts); H. Möhl's comparison, microscopical examination, and description of a collection of typical basalts (pl. xi.); Ant. del Castillo and Burkart on a new bismuth mineral; and A. von Lasaulx on the so-called "hemithrène" and some other rocks from the gneissic plateau of the Dep. Puy de Dôme.

Jahrgang 1875, Hefte 1–9. The original memoirs in this volume are—

For Palæontology:—Eugene Geinitz on a new exposure of bituminous shale in the Lower Dyas (Permian) of Weissig near Pillnitz, Saxony; among the fossils figured in pl. i. is a new Insect (*Blattina porrecta*) and a new Fern (*Sphenopteris Weissigensis*); F. Toula on some Permio-carboniferous fossils from the West Coast of Spitzbergen (woodcuts and pls. v.–x.); F. Maurer on the fossils of the Devonian red-ironstone of the Haina Mine, Rodheim (pl. xiv., *Strophomena irregularis*, F. Roemer, and *Amplexus biseptatus*, F. Maurer); H. B. Geinitz on *Knorria Benedeniana* from the Belgian Coal-formation (pl. xv.).

For Geology:—A. Baltzer on a late landslip on the Rossberg, and on similar occurrences in the Alps (woodcuts); Silvestri on the eruption of Etna on Aug. 29, 1874; Th. Wolf, Geological notes on Ecuador: 4. the volcanic eruptions and earthquakes in Ecuador since the Conquest; A. Pichler on the Trias of the northern limestone Alps of the Tirol; C. W. C. Fuchs on the geology of Meran and the neighbouring districts in the German Alps (pl. xvi. Geological map); F. W. Noak on the formation of continents (woodcuts); A. Pichler on the geology of the Tirol: 1. Porphyrites; 2. Granite of the Brixen; 3. Porphyry of Botzen; 4. Porphyritic schist; 5. Micaceous clayslate; 6. Dolomite of the Cislon; 7. Cardita-beds; 8. The Sonnenwendjoch; 9. Laumontite, &c.; Mohr on the cause of the Earth's internal heat.

For Mineralogy and Petrology:—A. Kenngott on the crystalline forms of quartz, and the trapezoedral tetartoedry of the hexagonal system (woodcuts); E. Cohen on some peculiar melaphyre-amygdaloids from South Africa, with sub-cylindrical or pipe-like kernels (pl. ii. and iii.); A. von. Lasaulx's mineralogico-crystallographic notes (pl. iv.); Ferd. Roemer on the Gonderbach Mine, near Laasphe, in the Wittgenstein Circle; F. Sandberger on clarite from the Clara Mine, near Shapbach, in the Baden Schwarzwald; H. Schröder on the atomic-constitution of some minerals; E. Kalkowsky's microscopical examination of the so-called micaceous trap of Metzdorf, proving that this is an altered grauwacké, and is not at all an eruptive rock; C. Klein's mineralogical notes: 13. Anatase; 14. Xenotine from the Binnenthal; A. Streng on the crystalline form and macles of Phillipsite (pl. xiii.); A. Frenzel's mineralogical notes; Möhl's microscopical mineralogical notes; A. Streng on the porphyrites of Ilfeld and vicinity.

The proceedings of the UPPER-RHINE GEOLOGICAL SOCIETY are also published in this volume of the *Neues Jahrbuch*; and among the more important of the miscellaneous letters to the Editors we may note:—

P. Strobel on the remains of Balænopteridæ in the Parma Museum; F. J. Kaufman on the Triassic and Jurassic fossils of the Mythenstöcke, near Schwyz, the Buochserhorn, and Stanserhorn, in Unterwalden; P. Strobel on the geology of the Andes between 33° and 35° S. Lat.; Renard on the plutonic rocks of Belgium and the Ardennes; A. Arzruni on the sulphur beds in Daghestan; H. Rosenbusch on the contact of granite and clayslate in the Vosges; G. vom Rath on the volcanic eruptions in Iceland in the winter of 1874-5; F. Zirkel's microscopic examination of volcanic ash which fell in Norway, March 29, 1875; A. Schrauf on wapplerite; Des Cloizeaux on perowskite, felspars, leucite, salite, eucrite, &c.; and H. Möhl on melaphyre, minette, and porphyrite.

REPORTS AND PROCEEDINGS.

I.—British Association for the Advancement of Science, Forty-sixth Meeting, Glasgow, September 7th, 1876. Titles of Papers Read in Section C. (Geology).

President.—Prof. John Young, M.D., F.R.S.E., F.G.S.

Inaugural Address by the President.

Dr. D. Milne-Home, F.G.S.—Notices of Terraces, Flats, and Haughs at High Levels in the Carron Valley, near Falkirk.

Dr. James Bryce, F.G.S.—Seventh Report on Earthquakes in Scotland.

Dr. James Bryce. F.G.S.—On the Earthquake Districts of Scotland.

His Grace the Duke of Argyll, K.T., LL.D., F.R.S.—On the Physical Structure of the Highlands in connexion with their Geological History.

Dr. D. Milne-Home, F.G.S.—Notes on the Parallel Roads of Glen Roy.

J. Macfadzean.—On the Parallel Roads of Glen Roy.

G. A Gibson, M.B., B.Sc.—On the Geology of Foula, Shetlands.

W. Pengelly, F.R.S.—Twelfth Report of the Committee for exploring Kent's Cavern, Devonshire.

R. H. Tiddeman, M.A., F.G.S.—Fourth Report of the Committee for assisting in the Exploration of the Settle Caves (Victoria Cave), Yorkshire.

E. Wünsch, F.G.S.—On the Junction of Granite and Old Red Sandstone in Arran.

Professor W. C. Williamson, F.R.S.—On the most recent Researches into the Structure and Affinities of the Plants of the Coal Measures.

Dr. Anton Fritsch.—On Labyrinthodont Remains from the Upper Carboniferous (Gas-Coal) of Bohemia.

Professor Harkness, F.R.S., and Professor H. A. Nicholson, M.D.—On the Strata and Fossils between the Borrowdale series of the Coniston Flags of the North of England.

Rev. E. Sewell, M.A., F.G.S.—Notes on the Drifts and Boulders of the Upper Part of the Valley of the Wharfe, Yorkshire.

C. E. De Rance, F.G.S.—Second Report of the Committee on Underground Waters of the New Red and Permian Formations of England.

W. S. Mitchell, LL.B.—Final Report on the Bagshot Leaf-beds.

Professor James Thomson, F.R.S.E.—On Ridgy Structure in Coal, with suggestions towards accounting for its origin.

Professor James Thomson, F.R.S.E.—Further Illustration of the Jointed Prismatic Structure in Basalts and other Igneous Rocks.

Rev. H. W. Crosskey, M.A.—Report on Distribution of Erratic Boulders.

Professor E. Hull, M.A., F.R.S.—On the Upper Limit of the essentially Marine Beds of the Carboniferous System in the British Isles, and the necessity for the establishment of a Middle Carboniferous Group.

[illegible] F.G.S.—[illegible] Sections exhibiting Variations of [illegible] in the [illegible]-Measures of West Lancashire.

[illegible] F.G.S.—On the Changes affecting the Southern Ex[illegible] Rocks.

[illegible]—On the [illegible] Limestone on the West Coast of [illegible].

[illegible]—On some New Minerals and on Doubly-refracting [illegible].

[illegible] F.G.S.—On the [illegible] Denudation Argument [illegible].

[illegible] F.G.S.—Siliceous Sponges from the Carboniferous [illegible].

[illegible] F.G.S.—On the [illegible] of Strath Errick and [illegible].

[illegible]—On the Upper Silurian Rocks of Lesmahagow.

[illegible] F.G.S.—On the Age, [illegible] and Mode of Occurrence [illegible] Deposits of the South of France. Lit. Dept. [illegible]

[illegible] F.G.S.—On a Deep Boring for Coal at [illegible].

[illegible]—On the Tertiary Basalt Dykes in Scotland.

[illegible]—On [illegible] and Metamorphosed [illegible] North Wales.

[illegible] Rocks.

[illegible] Sussex.

[illegible]

18. "Some Recent Sections near Nottingham." By the Rev. A. Irving, B.A., B.Sc., F.G.S.

The author describes a section of the strata exposed during the recent construction of a railway line from Carlton, three miles to the east of Nottingham, through Daybrook, to Kimberley.

The section commences in the Upper Keuper; the Lower Keuper (Waterstones) are penetrated at a short distance from the village of Gedling. These beds are well shown as the cutting enters the plateau known as the "Mapperley Plains," and consist of a series of alternating red marls and sandstones. One of the sandstone-beds is nearly white; and hollows varying in size from that of a pea to that of a fowl's egg are of frequent occurrence. These are probably due to the dissolving out of small calcareous concretions. This bed occurs high up in the Waterstone series. The total thickness of the Lower Keuper may be estimated at about 100 feet. At about one quarter of the height from the bottom ripple-marks are abundant; sun-cracks, rain-pittings, and pseudomorphs also occur; but as yet no footprints have been found.

The line then crosses about 3 miles of Bunter country. In the upper portion of the series the pebble-beds appear to be wanting, and their place is taken by a series of thinly-laminated, micaceous, whitish, false-bedded sandstones. These are succeeded by marine conglomeratic beds, which extend for some distance. A mile further west the sandstones become softer, and assume a more mottled appearance, which they retain all the way to the Leen Valley, where the base of the Bunter is hidden by alluvium.

The cutting then passes through an outlier of Lower Bunter and Upper "Permian" Sandstone. Two faults occur at this spot, by the first of which the Permian is thrown down several yards; whilst by the second it is let down below the level of the railway.

Near the village of Watnall a tunnel pierces the Magnesian Limestone and the Coal-measures. This junction is distinctly unconformable, the Permian formation being nearly horizontal, and the Coal-measures dipping at an angle of 15° to the north-east. At the western end of the tunnel another fault lets down the Permian 12 feet; the Coal-measures are consequently lost to sight, until again brought up by another fault on the other side of the village. The author considers that the Permian strata are closely related to the overlying Trias, and are unconformable to the Coal-measures.

Here and there patches of drift were met with, but almost entirely in the Bunter country, owing to the friable nature of that deposit. These patches are probably the remnants of a drift once more widely spread.

Traces of drift on the Keuper country are remarkably few. Two patches have been preserved by a fault on the north-eastern side of Nottingham.

In a cutting on a new line of the Midland Railway it is found that the *Avicula-contorta* shales have been removed by evident glacial action, and redeposited among other materials on the planed and striated surface of the indurated greenish-grey marls of the lowest Rhætic strata.

19. "On the Permians of the North-east of England and their relations to the Under- and Overlying Formations." By. E. Wilson, Esq., F.G.S.

The author describes as follows the same section as that noticed in the preceding paper:—Lower Bunter, 30 feet; breccia of various slates and grits, etc., underlain by red and yellow mottled and grey sandstones, considered by the author to be passage-beds between the Bunter and the Permian formations; these are followed by ordinary Permian marls, 21 feet; Magnesian Limestone, 33 feet; slate-coloured thin-bedded sandstones and shales, with a breccia at the base, 19 to 20 feet. The breccia rests in a series of very gentle undulations on a planed-off surface of Coal-measure shales, which dip in a north-easterly direction at an angle of 15°. This unconformity between the Coal-measures and the almost horizontal Permians is most pronounced, a fact long ago pointed out by Prof. Sedgwick, and tends to confirm the supposition of the pre-Permian elevation and denundation of the Pennine axis.

The author considers the breccia at the base of the Permian, and possibly that of the Lower Bunter, to be of glacial origin. The paucity of life in the intervening beds might thus be accounted for.

20. "The Section at High Force, Teesdale." By C. T. Clough, Esq., B.A., F.G.S.

The section described by the author in descending order is as follows:—Basalt, 24 feet; altered shale, 1¼ foot; basalt, 6 feet; altered shale, 12 feet; limestone, 32 feet. The second stratum of basalt has been erroneously described in Phillips's 'Geology of Yorkshire' as "plate" or shale, whereas it is merely an underflow of the basalt. About 20 yards below the Force the lower and intercalated layer of basalt has entirely disappeared. These intercalated (not interstratified) beds of volcanic rock are common throughout the district, and tend to prove the irruptive nature of the Whin Sill, as maintained by the late Prof. Sedgwick.

21. "The Distribution of Flint in the Chalk of Yorkshire." By J R. Mortimer, Esq. Communicated by W. Whitaker, Esq., F.G.S.

The author considers that the present shape of the Chalk Wolds of Yorkshire seems to suggest that they are the remains of an atoll or circular reef, probably one of a chain, rather than the fragment of a vast sheet of Cretaceous mud deposited in deep water. He thinks that the flint-bearing and non-flint-bearing chalk areas are in the main contemporaneous in Yorkshire. The chalk without flint contains 4·28 per cent. of silica, whilst the chalk with flint contains only 2·12 per cent.

22. "On the Mode of Occurrence and Derivation of Beds of Drifted Coal near Corwen, North Wales." By D. Mackintosh, Esq., F.G.S.

Resting on the lowest drift, which here, at an elevation of 500—600 feet below the level of the sea, consists of yellowish clay alternating with beds of coarse gravel, is a deposit of clean sand and ne gravel, containing streaks and layers of coal, which varies in rm from fine dust to large lumps. The fine gravel appears to be tirely made up of local micaceous Silurian grit.

The glacial striæ run in a W.S.W. direction, and at first led the thor to infer that the coal had been drifted from that quarter. his, however, would have involved the supposition that a portion of e Coal-formation *in situ* had been faulted down on the top of the markable outlier of Mountain Limestone, which occurs about a ile and a half west of Corwen. The author is therefore now of e opinion that the coal was drifted from the Ruabon district during comparatively temperate interglacial period. The land not being bmerged beyond a few hundred feet, it was floated along the sinu-sities of the valley of the Dee, and stranded in the shallow water of e Corwen area. Hence the transportation of débris may at times ave taken place in a direction diametrically opposite to that of the laciation of a district.

23. “The Cephalopoda-beds of Gloucester, Dorset, and Somerset.” y J. Buckman, Esq., F.G.S.

The author considers the Cephalopoda-beds of Bradford and undry to be on the same horizon, and that neither the one nor the her have the slightest connexion with the Cephalopoda-bed of loucestershire. The Dorsetshire Cephalopoda-bed is the equivalent f the “Gryphite Grit” at Leckhampton, and the overlying roughly edded stone is the representative of the “Trigonia Grit” of Cold omfort. The Gloucestershire Cephalopoda-bed lies at the base of e Inferior Oolite, whilst the Dorsetshire bed is at the top of that rmation.

Part of the sands at Bradford Abbas really represent the lower olitic mass of Leckhampton and Crickley; in fact the Dorset sands present the lower freestones of Gloucestershire. The beds underying the Dorsetshire Cephalopoda-bed are the equivalents of the ferior Oolite of Ham Hill.

The author gives lists of the fossils from the freestone of Ham ill, and of the Cephalopoda from the Dorset equivalent of the Gryphite Grit.” The latter do not appear in zones, but different pecies are prevalent at different localities, all on the same horizon. he other fossils from this bed point to the same conclusions, as the mmonites are numerous and in good preservation.

24. “Evidence of the Subsidence of the Island of Guernsey.” y R. A. Peacock, Esq., C.E., F.G.S.

All round the coast of this island, like that of Jersey, are found ee-trunks and other vestiges of old forest-land now submerged. assages are quoted by the author from various old historians relative the former existence of this tract of dry land, the submergence which probably took place in the fifteenth century. The encroachent of the waters is due to the subsidence of the land, and not, as as been suggested, to the breaking in of the sea through some atural barrier upon some already low-lying district. Judging from e old chart of 1406, the amount of depression is equal to 160 feet.

CORRESPONDENCE.

INTER-GLACIAL MAN.

SIR,—Will you allow me to record the discovery of Palæolithic flint implements, mammalian bones, and fresh-water shells in brick-earths below the Boulder-clay of East Anglia?

The great chalky Boulder-clay of this district I have shown in two Geological Survey Memoirs, now in the press, to belong to the early part of the Great Ice Age, and only to be "Upper Glacial" in so far as this district is concerned. Beneath this clay occur patches of brick-earth which may be of "Middle Glacial" age or even older, and from them I have obtained well-fashioned flint implements. These tools are the oldest yet described, although some of the well-known cave implements may be as old or older, their antiquity being doubtful, from the absence of Glacial deposits. The human remains from the Victoria Cave at Settle, beneath Glacial Clay, are in all probability of the same age as our Palæolithic gravels, and hence much newer than those in question.

I hope shortly to describe these interesting relics and their geological position fully. SYDNEY B. J. SKERTCHLY.

H. M. GEOLOGICAL SURVEY, BRANDON,
September 1st, 1876.

THE STAINING OF ROCKS BENEATH THE MAGNESIAN LIMESTONE.

SIR,—Immediately below the Magnesian Limestone of Yorkshire there is a belt of shales and sandstones more or less red or purple in colour. For a long time these rocks were looked upon as a subdivision of the Permian Group, the main reason for placing them on that horizon being their marked red hue, which contrasts strongly with the blue or grey tints of the generality of the Carboniferous shales and sandstones. It is now, however, well known that these red beds are stained Carboniferous rocks, and as the staining is confined to the portions which are now capped by Magnesian Limestone, or which were probably once overlaid by that formation, there is good ground for believing that the Magnesian Limestone has had something to do with the change in colour. It seems likely that the effect has been produced by water, which has percolated through the Limestone and passed down into the stained rocks.[1]

In the hopes of throwing some light on the nature of the chemical reactions by which the change in colour has been brought about, I made the following experiment: Water saturated with carbonic acid gas, and containing finely divided limestone, was dropped slowly on lumps of gritstone in such a manner that very small quantities of the powder dropped at the same time. After the process had been continued for about six weeks, the stone was found to be stained dark red, and the staining was particularly marked in the bluish grey varieties. The quantity of the colouring matter was too small to allow of its being analysed, but it seemed to me likely that some salt of iron, probably the carbonate, was dissolved in the water, and precipitated by the carbonate of lime and magnesia as per-hydrate of iron.

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[1] J. C. Ward, Quart. Journ. Geol. Soc. vol. xxv. p. 295; GEOL. MAG. Vol. IX. p. 389. J. Lucas. GEOL. MAG. Vol. IX. p. 338. For another case of rock staining *see Mems.* of Geol. Survey of Great Britain, vol. i. p. 45.

In order to test the correctness of this explanation, I passed carbonic acid gas through water containing powdered grit, powdered limestone, and a mixture of the two; and since the stone that was stained was freely exposed to air and light, I was careful that the powders should be exposed in a similar manner. The powders were then allowed to dry and fresh water added. The process was repeated during several months, but in none of the three cases could I find a trace of iron in the liquid.

I am led to ask for a publication of my results, in the hope that some of your readers will suggest some other test experiments which may lead to the true explanation of the method by which the staining is produced. James Monckman.

Yorkshire College of Science, Leeds.

LLANDOVERY ROCKS IN THE LAKE DISTRICT.

Sir,—I notice that Mr. Hicks, in his last letter on this subject, is contented to meet his opponents on their own terms, and that he expresses his firm persuasion of the overthrow of their views solely by the evidence afforded by the Brachiopods and Trilobites which have been discovered in the disputed beds within the last few months. It may consequently be suspected that the Graptolites which swarm in these beds, but which have been so slightingly alluded to and hurried out of sight, have not a word to say upon the question. I am still, however, inclined to think that a good case can be made out by the aid of the Graptolites alone; and that the view of the Lower Llandovery age of the Coniston Mudstones, grounded upon this opinion, which I have held for some years, and which was strongly insisted upon in a joint-paper on the Coniston Group by Professor Nicholson and myself, read at the Bristol Meeting of the British Association (1875), needs but little extra confirmation.

I presume that most palæontologists are willing to admit that, whether the various genera and species of the Graptolites are of equal systematic value with those of the Brachiopoda and Trilobita or no, they are at least as easily identified by those who have studied them, and that it is tolerably certain that they were correspondingly affected by the conditions which brought about the gradual evolution and extinction of the various forms of the latter groups, whose remains are now found upon the same horizons with them. If so, it is surely highly unphilosophical to refuse to allow full value to those points now known with a close approximation to certainty regarding the presence and range of the Graptolites which all would be willing to grant at once, where the other groups are concerned. Following here, therefore, the usual line of argument adopted when the latter are relied upon as indices of the systematic place of their containing beds, we observe—

Firstly—(*a.*) The Coniston Mudstones consist of a thin group of shales (black below, and grey or purple above), which reposes upon a limestone containing many of the very highest Bala fossils, and which yields a very distinct assemblage of Graptolites (about 25 species), a few of which are confined to its lower beds, and a few occur only in its highest zones.

(*b.*) In the neighbouring Silurian district of South Scotland is found a bed of precisely similar lithological character (the Birkhill Shales), black below, and grey, purple and black above. In these shales perhaps every fossil of the Mudstones is represented; and, strange to say, they have a similar vertical distribution; the forms peculiar to the top beds of the Mudstones being also strictly confined to the highest bands of the Scotch deposit. Now these Birkhill Shales are said by the officers of the Scottish Survey to be imbedded in strata of Upper Llandeilo age.

(*c.*) The same beds, with nearly all the same fossils arranged in the same way, are continued into Ireland, where they emerge from below a great thickness of almost barren grits, regarded by the Irish Survey as of Bala age; while the black band itself is said to belong to the Llandeilo.

(*d.*) The characteristic Graptolites of the Mudstones can be collected in abundance in the highly prolific beds of Pomeroy, which yielded to Portlock the magnificent series of Irish fossils figured in his Report, and which have subsequently been looked upon as undoubtedly of Bala age.

(*e.*) The same group of Graptolites occurs in the Kiesel Schiefer of Thuringia—a band of black and grey shales which plunges below the great mass of the Middle Silurian rocks of that district.

(*f.*) Many of the most characteristic species (unmixed with earlier or later forms) swarm in the very lowest band only of Linnarsson's Upper Graptolite Schist of Sweden, which reposes immediately upon calcareous beds with Bala fossils.

Thus, on the assumption that the authoritative correlations made by the Scotch and Irish Surveys are correct, this especial group of Graptolites has hitherto been met with only in strata that (i.) underlie the chief mass of the Middle Silurian, (ii.) lie immediately above the Bala limestones, (iii.) are imbedded in the main Bala series, or (iv.) form a portion of the Upper Llandeilo.

Secondly—(*a.*) The Birkhill Shales aforementioned are separated from the true Upper Silurian of Scotland (with Wenlock fossils) by a massive series of rocks (the Gala group), containing many Graptolites, some of which are Coniston Mudstone forms, others peculiar, and others common to the Upper Silurian.

(*b.*) Similar rocks floor the counties of Down, Louth, and Cavan, and repose on the Mudstone equivalents already noticed. They contain also a similar mixture of Birkhill, Gala, and Upper Silurian Graptolites, but nowhere show any clear trace of overlying Upper Silurian strata.

(*c.*) Rocks of the same nature, and of great collective thickness, surmount the Thuringian Kiesel Schiefer, and contain some of the same transitional Graptolites in association with a mixed group of Lower and Upper Silurian Brachiopoda.

(*d.*) The lowest bed of the Upper Graptolitic Schist of Sweden, ining the chief Mudstone Graptolites, is covered up by a second tolitic schist, with transitional forms, and that is followed in by a limestone containing a preponderance of Llandovery fossils.

) The Colonies and the Band E. e. 1 (asserted by Salter to be of dovery age) of Barrande's Silurian Basin of Bohemia contain an xture of the Mudstone Graptolites with transitional and Upper ian forms; the first-named making up, perhaps, about one-of the total Graptolitic fauna.

e see, therefore, that the beds containing the typical Coniston stone fauna are followed in Ireland, Scotland, Germany and len, by rocks containing many new forms, and having a general principally composed of an admixture of Lower and Upper ian species; and that the transitional and supposed Upper ian Graptolite-bearing zone of Bohemia, hitherto looked upon as quivalent of the Mudstones, and sometimes instanced as proof ive of the possibility of their Upper Silurian age, is, on the ary, of far more recent date.

iirdly—(*a*.) None of the Graptolites of the Mudstones survive the true Upper Silurians of the succeeding Coniston Flags.[1]

.) All the corresponding Birkhill fossils have died out before we the Upper Silurians of South Scotland.

) Not one of the Graptolites yielded by the Kiesel Schiefer er of Thuringia occurs in the unequivocal Upper Silurian of the ibouring district of Bohemia (Band E. e. 2 of Barrande).

.) None of the Mudstone Graptolites are met with in the lock or Ludlow beds of Shropshire and Hereford.

ie Upper Silurian beds here cited contain Graptolites in great dance, so that the absence of the Mudstone forms cannot be ined away by reference to non-suitability of habitat or the like; it must be recollected that the Graptolitic faunas of these widely rated Upper Silurians are practically identical. Hence on any it is evident that the period of time which intervened between lose of the typical Mudstone epoch and the commencement of of the true Upper Silurian was sufficiently lengthy to admit of radual dying out of all the Mudstone Graptolites and the con-oraneous evolution of their Upper Silurian successors. If this be the chief break in the Lake District is not between the Lime-s and the Mudstones, but between the latter and the Coniston s. In Westmorland we may form some little idea of its mag-le by the marvellous change it wrought upon the Graptolites; n Scotland and Germany by the thick and far-spreading masses ose Middle Silurian rocks, of which we have little or no trace in ake-district itself.

iat the Coniston Mudstones are not of Bala age is tolerably from their position with reference to the Coniston Limestones; if Mr. Aveline is right in his opinion that there is a slight ical break between the two groups, this may be regarded as nstrated. Again, that they are not of Upper Silurian age is d beyond doubt by the complete absence within them of Upper

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[1] With one exception, *M. Hisingeri*, Carr.

Silurian Graptolites; and, finally, the fact that their equivalents are everywhere separated from the equivalents of the Wenlock Rocks by the main mass of the Middle Silurian, leaves us no choice but to assign them to the Lower Llandovery. CHARLES LAPWORTH.

ST. ANDREWS, *Sept. 9th.*

SECTION OF BOULDER-CLAY, NORTH DOCKS, LIVERPOOL.

SIR,—The sections described by Mr. Mackintosh in the September Number of the GEOLOGICAL MAGAZINE are, as he says, well worthy of study. They were visited by the Liverpool Geological Society in June last: at that time the section showing the Lower Boulder-clay of Mr. Mackintosh was well developed. It was simply a clay containing more stones and of a harder nature than usual, separated from the clay above, which is more plastic and free from stones than is generally the case, by a seam of sand and gravel. Several of our members were rejoiced at having at last discovered that for which they had previously for years searched the neighbourhood in vain, viz. the veritable Lower Boulder-clay. I ventured to doubt if the section before us was sufficient evidence to support the tripartite division of the Boulder-clay now in fashion; and I expressed the opinion that the distinction would not be maintained over any considerable area, and that the lower clay was simply a local variation of the upper; in fact, that the deposit was one and the same. A short time since I again visited the Docks, this time in company with Mr. Bristow, Mr. Aveline, and Mr. De Rance. The latter gentleman, who is well acquainted with the excavations, was desirous of showing us a section of some curiously contorted gravels, and took us to the exact site of the previous Lower Boulder-clay section, but—though certainly not to my astonishment—both contorted gravels and Lower Boulder-clay had disappeared. The fact is, the beds are thrown about so irregularly that there is no dependence to be placed on their continuity. A few yards more or less of excavation changes their character so, that what before appeared separate and distinct beds shade into one another by imperceptible gradations, thin out, or, as not uncommonly happens with beds of sand or gravel, stop short off with a square end. My friend Mr. De Rance, if my memory serves me, also expressed the opinion that there was no Lower Boulder-clay in the dock. So far as the Boulder-clay deposits about here affect the question, I have arrived at the mature conviction, after long study, that between the red sand or rock on which they rest and the surface they are an unbroken series of marine deposits, laid down during the subsidence of the land and its subsequent re-elevation, and that for an explanation of the curious manner in which they are bedded we must look to the varying directions of the tidal currents as affected by the degree of submergence at the time, and the contours of the then land.

4, SOUTH JOHN STREET, LIVERPOOL, *Sept. 12th.* T. MELLARD READE.

ERRATUM.—In Mr. BONNEY'S letter, p. 377, lines 30, 31, from top of page, for "therefore it is to be applied," read "it is *not* therefore to be applied."

Dr. OLDHAM begs us to delete, at p. 384, the letters C.B. after his name. We apologize for the error. EDIT. GEOL. MAG.

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ORIGINAL ARTICLES.

-On the Gondwana Series of India, as a Probable Representative of the Jura-Triassic Epoch in Europe.

By Ottokar Feistmantel, M.D.,
Geological Survey of India.

INCE Sir Charles Bunbury described the Flora of Nagpúr,[1]
drawing the most rational conclusions, and since Messrs. Old-
m and Morris illustrated a portion of the Flora of the Rajmahal
ries in the Rajmahal Hills,[2] nothing of importance has come before
public regarding the Flora of the Indian Plant-bearing Series,
hough the then abundant material has subsequently been con-
erably increased through the exertion of the officers of the Geolo-
al Survey of India, who have also done much to explain the geo-
ical relations of the whole Series.

From them we learn[3] that portions of this great system, either
larger basins or in smaller patches, extend generally from the
jmahal Hills in the east through Central India into Kachh in
west. Also from this general direction southwards through the
davari District, as far as the neighbourhood of Madras; being
nd again on the south-east coast from Madras to Orissa.[4]

The former name of the beds, *i.e.* "Plant-bearing Series," is no
ger accurately appropriate; for the association of a portion of the
ks with animal organisms is proved.[5] I therefore adopt the more
ent name of "Gondwana Series," proposed by Mr. H. B. Medli-
tt,[6] for these rocks, as it contains no presumptive indication of the
sil remains, and conveys an idea of collectiveness—all the strata,
fact, belonging to one great Mesozoic epoch.

Dr. Oldham has given us a paper on the probable age of some of
ese beds;[7] but when he wrote it, only the Flora of the Rajmahal
ills had been closely examined, and the lists of the fossils from

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[1] Quarterly Journ. Geol. Soc., vol. xvii. pp. 325–346, pl. viii-xii.

[2] Palæontologia Indica, 1862, vi. fascic., xxxv. plates, 52 pages.

[3] See the different volumes of the Memoirs and Records of the Geological
rvey of India.

[4] I have indicated it a little nearer in Rec. Geol. Surv. of India, vol. ix. No. 2.

[5] The Kachh Beds with marine and terrestrial animals, the Jabalpúr Group with
restrial, also the Kota and Maléri Beds; the Sripermatur Group with plants and
rine fossils, and the Panchet Group with pretty frequent terrestrial fossils.

[6] Proposed some years ago.

[7] Mem. Geol. Surv. of India, vol. iii.

other places were only approximate. They have been, however, reproduced in the same sense more recently by Mr. H. F. Blanford.[1]

Previously to this, the animal remains in the Panchet Group were worked out, and declared as probably Triassic, by Professor Huxley,[2] and Dr. Oldham had described certain species of *Ceratodus* from some of these rocks as most probably Liassic.[3]

Later still Dr. Waagen worked out the Cephalopoda of Kachh,[4] almost the only place where distinct marine fossils occurred abundantly in beds which also contain plants.

But the greater number of the Gondwana plants, generally speaking the prevailing fossils, remained undescribed and unexamined.

Owing, as it appears to me, to one or the other of the more common genera having been studied first, a wrong comparison was instituted between one part of our Gondwana Series and the Australian Coal-measures, and hence the inference was inadequately drawn[5] that this Indian Series was also of Palæozoic age. I hope now to place this matter in a better light after a year and a half's study of these fossils.[6]

The Gondwana Series is separated into two portions:—1. Upper or newer portion. 2. Lower or older portion.

1. The upper portion comprises that which Dr. Oldham formerly denominated the Rajmahal Group,[7] but which the examination of the fossils has proved to contain at least two different groups. Of these one may be called the Rajmahal Series; and the other, which is newer, may be named the Kachh Series.

True Rajmahal beds occur in the Rajmahal Hills,[8] near Atgurh (Cuttack),[9] and in the Godavari District near Golapili[10] (Ellore).

The Kachh Series comprises the Kachh plant-beds, with marine and terrestrial animal fossils, and the Jabalpúr Group, beginning in South Rewah, passing Jabalpúr, and spreading out into the Satpura Basin. This latter contains both plants and terrestrial animals. Besides the above, the upper beds would also include the Sripermatur Group near Madras[11] (Mr. Foote), and Rajavapuram (Mr. King),[12] which contains plants and marine animals, and is most likely intermediate, but next to the Rajmahal Series; also the small patch near Taparazpilly Cotta (Coconada) with marine fossils, which represents the upper beds in Kachh. Lastly the Kota and Maléri beds, which lately

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[1] Quart. Journ. Geol. Soc. 1875, pp. 519–542.

[2] Palæontol. Indica, 1865 (4, 1).

[3] Mem. Geol. Surv. India, vol. i.

[4] Palæontol. Indica, 1873–75.

[5] Dr. Oldham, Mem. Geol. Surv. India, vol. ii.; H. F. Blanford, Quart. Journ. Geol. Soc., 1875; W. T. Blanford, Rec. Geol. Surv. India, vol. ix. No. 3.

[6] See my notes in Jahrb. d. k.k. geol. Reichsanst. Wien, 1875, and in Rec. Geol. Surv. India, vol. ix. Nos. 2 and 3.

[7] Mem. Geol. Surv. India, vol. ii.

[8] Oldham and Morris, Pal. Indica, 1862; Feistmantel, Rec. Geol. Surv. India, vol. ix. No. 2.

[9] Fossil plants brought by Mr. Ball this year (1876).

[10] Fossil plants collected by Mr. King—mentioned by me in Rec. Geol. Surv. India, vol. ix. No 2.

[11] Mr. Foote, Mem. Geol. Surv. India, vol. x. p. 100. Fossils sent by him.

[12] Fossils collected and sent by Mr. King.

.ave been found identical,[1] and which contain abundant remains of errestrial animals, ought also to be placed here.

2. The lower portion of the Gondwana Series contains:

a. The Panchet Group, as it is best known, in the Raniganj field,[2] with its flora[3] and terrestrial fauna.[4]

b. The Damuda Series, stratigraphically separated again in three ubdivisions (Kamthi or Raniganj Group—Iron Shales—and Baracur Group), which, however, palæontologically cannot be distinguished,[5] as the same fossils are found in them throughout.

The Damuda Series is the most largely developed in Peninsular India, and has only been found in one place in the Himalayan region (in Sikkim).

We find these rocks in the Rajmahal Hills (west side), in the Raniganj (or Burdwan) Coal-field, in the Kurhurbari, Deoghur, etc., Coal-fields; near Cuttack (Orissa), in the Satpura Basin, Nerbudda Valley, in the Nagpúr District, in the Chanda District (Wurdha Coal-field), and through the whole Godavari District. This Series is marked by a Flora only, which I could very easily identify with an European one.

c. The Talchir Group of the Survey classification I consider not far distant from the Lower Damuda beds,[6] which they generally accompany.

I. *Fossil Remains of the Upper Portion of the Gondwana Series.*

While the Jabalpúr Group contains a Flora, only lately found associated with some terrestrial animal fossils,[7] the Flora of Kachh occurs to a great extent in the highest marine fossil-bearing beds, also partly in a lower horizon[8] (near Nurha); but in all these three districts, in the Jabalpúr Group, in the upper and lower horizon in Kachh, the Flora (and the terrestrial animal fossils) correspond so closely that I could not make any distinction in their age.

a. The lowest beds in Kachh abound in *Cephalopoda* and other Mollusca, generally speaking, of Middle Jurassic age. The *Cephalopoda* have been already described by Dr. Waagen, the other Molluscs yet await examination and description.

Amongst these Middle Jurassic Marine beds of Nurha,[9] the Flora of Kachh appeared first, and is represented by the following species: *Alethopteris Whitbyensis*, Göpp.; *Sphenopteris arguta*, L. & H.; *Otozamites contiguus*, Fstm.; and *Araucarites Kachensis*, Fstm. (near *Araucar. Phillipsi*, Carr.).

So far the age of the Flora is established; but it continued to live possessing the same character, while younger animal forms appeared.

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[1] T. W. Hughes, Rec. Geol. Surv. India, vol. ix. No. 3, p. 86.

[2] W. T. Blanford, Mem. Geol. Surv. India, vol. iii.

[3] Feistmantel, Rec. Geol. Surv. India, vol. ix. No. 3, pp. 65-67.

[4] Huxley, Pal. Indica, 1865 (4, 1).

[5] Rec. Geol. Surv. India, vol. ix. No. 3, p. 68.

[6] *Ibid.* vol. ix. No. 3, pp. 77-79.

[7] Hughes, Rec. Geol. Surv. India, vol. ix. No. 3.

[8] Wynne, Geology of Kachh, Mem. Geol. Surv. India, vol. ix. pt. 1.

[9] North-west of Kachh.

The Flora in this higher horizon became also more numerous. I have determined and described about 26 species, amongst which the most important are: *Oleandridium vittatum*, Schimp. (Bgt.); *Alethopteris Whitbyensis*, Göpp.; *Pachypteris specifica*, Fstm.; *Actinopteris*-like forms; *Ptilophyllum Cutchense*, Morr., and varieties; *P. acutifolium*, Morr.; *Otozamites*, comp. *Goldiæi*, Bgt.; *Williamsonia Blanfordi*, Fstm.; *Palissya indica*, Fstm.; *Pachyphyllum divaricatum*, Bunb. sp.; *Echinostrobus expansus*, Schimp.; and scales of *Araucarites Kachensis*, Fstm. (very closely allied to *A. Phillipsi*, Carr.).

We find here, therefore, species, which I mentioned also from the lower horizon at Nurha.

The genus *Ptilophyllum*, Morr. (*Palæozamia*,. Endl.), prevails, a genus altogether an Indian type, and common to both groups of the upper portion of the Gondwana Series, which only shows that they both belong to the same epoch.

Echinostrobus expansus, Schimp., the English Lower Oolitic species, and scales of *Araucarites*, are also pretty frequent.

The Flora exhibits therefore altogether a middle Jurassic character.

In addition to other marine fossils from the upper portion of the beds of Kachh, these rocks have furnished also a vertebra of *Parasuchus*, which is so frequent in the Maléri and Kota beds, and a front portion of a lower jaw of a *Plesiosaurus*, having the most affinity with Liassic forms: (similar indications of age occur in the Jabalpúr Group—see further on).

b. The Jabalpúr Group in South Rewah, Jabalpúr, and Satpura Basin, contains only Flora, without association of marine forms; but I cannot help stating that I recognized among the Flora, which I have just prepared for publication in the Rec. Geol. Surv. India, vol. ix. No. 4, a good many species identical not only with those in Yorkshire, but also several common with those in the Kachh beds, from which I infer that all these beds are of the same age. About the Jabalpúr Flora nothing has as yet been published, nor shall I enumerate it here, but only state that among about 26 species, 10 are identical with species from the English Oolite, while one species is Liassic, and all the others are of Jurassic type.

There is therefore an Oolitic Flora in these Kachh-Jabalpúr beds, in Kachh associated with animals partly of younger age; while no such association is found in the Jabalpúr Group, which, on the contrary, has been lately found by Messrs. King and Hughes in the Wurdha Coal-field associated with terrestrial animals, indicating in Europe generally Keuper or Lias, and here also considered to be of Liassic age.

In my descriptions I take these beds as of Oolitic age. Representatives of the upper beds of Kachh are found also on the south-east coast of India, near Coconada (Mr. King's Trigonia bed), and there is perhaps an analogy with the upper portion of the Uitenhage formation in Africa,[1] which contains some similar forms of *Trigonia*, formerly reported as Cretaceous by Krauss, but afterwards proved to ɘ of the age of the Great Oolite by Sharpe and Tate, from which we ɩay again draw conclusions regarding our Kachh beds containing ery closely allied fossils.

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[1] Tate, Geology of South Africa, Quart. Journ. Geol. Soc. 1867, vol. xxiii. p. 139 ff. *Tate, as Sharpe before, proves that this group is of the age of the Great Oolite.*

Dr. Waagen, on the other side, proves also an identity of several ɔecies in these upper Kachh beds with European Triassic[1] forms.

This is also again repeated by W. T. Blanford.[2] Forms related ɔ some of the plants in the Kach beds are found too in Dhagestan ɒd in Russia (Ekaterinoslaw), by which the connexion of the Flora ɾith that of Europe seems to be still more established.

c. The Rajmahal Series were first and best known from the ˈajmahal Hills,[3] where a typical and very well marked Flora is the ɒly record of former organic life.

A luxurious growth of large Cycadeous plants, as *Pterophyllum, ˈycadites,* such as we find generally only in Liassic deposits, covered ıe area; while the Indian type, *Ptilophyllum,* Morr. (*Palæozamia,* ˈndl.), already began to live here, was very abundant, and survived ˈll the time when the Jabalpúr Group and Kachh beds were depo.ted. We have therefore with this a genus and two species from the lder Rajmahal Series equivalent to the newer Kachh Series. The ˈerns, too, were rather abundant, and indicate distinctly a connexion ɾith the European Rhætic and Liassic time, supported especially by ɔme *Alethopterides,* and most frequently large *Tæniopteris*-leaves *ˈMacrot. lata, Morrisi,* etc.), and others, which indicate a distinct ıiassic character. This is further established by some species of *ˈtozamites,* particularly *O. Bengalensis,* Schimp., very near to *O. ɾevifolius,* Braun, by some *Coniferæ,* by an *Equisetum* (*E. Rajmaɑlense,* O. M., sp. Schimp.), which by Schimper[4] is considered as ɔnnected with Rhætic forms, and by Schenk[5] as a Liassic represenıtive. The Flora of Atgurh[6] contains only Rajmahal Ferns, and ıat of Golapili,[7] Godavari district, agrees completely with the plants f the Rajmahal Hills.

The Rajmahal Series were therefore principally deposited in the ˈajmahal Hills and along what is now the south-east coast of India.

As a peculiar fossil plant of these Rajmahal Series may be ıentioned what Prof. Morris describes as *Dictyopteris falcata,* var. *ɔtusa*; but which Dr. Oldham had previously supposed to be a *ˈamia,* proposing the generic name *Dictyozamites* for it. This is now ıdeed proved, and I have described this fossil as *Dictyozamites ıdicus,* Fstm., taking both varieties as the same.[7]

There seems to be also a slight analogy between our Rajmahal eries and the lower portion of Tate's Uitenhage formation of South .frica, just below the Trigonia bed there.

d. The Sripermatur Group of Mr. Foote, of equal age with the beds of Rajavapuram, seems to me an intermediate formation between the Kachh and the Rajmahal Series. They are not sufficiently examined as yet to speak with certainty on this point.

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[1] Palæont. Indica: Cepalopoda of Kachh, 1873-76.

[2] Records Geol. Surv. India, vol. ix. No. 3.

[3] Oldham and Morris, Pal. Indica, 1862.

[4] Pal. végét. vol. i. p. 276; vol. iii. p. 652.

[5] Flora der Greuzschichten, 1867, pp. 15, 20.

[6] Only lately brought by Mr. Ball, therefore not yet published; also not to ɘ mentioned here.

[7] Feistmantel, Rec. Geol. Surv. India, vol. ix. No. 2.

In considering the upper portion of the Gondwana Series we have the following list of groups and their relations:

Northern Part of the Peninsula of India.	South-east Coast of India.	West Asia.	Europe.	Africa.
1. Jabalpúr and Kachh Groups. Plants; marine and terrestrial animals (Oolite)	Beds near Coconada. (Trigonia bed of Mr. King.)	Dhagestan (Plants).	Russia, Germany, etc. Yorkshire.	Upper portion of the Uitenhage Formation (Trigonia bed).
—	Sripermatur Group, near Madras and Rajavapuram (Plants, animals).	—	—	—
2. Rajmahal Hills. Plants only (Lias).	Atgurh. Golapili (Plants).	North Persia (Plants).	Alps, Fünfkirchen, Banat, Whitby? (Plants).	? Lower portion of the Uitenhage Formation (Plants).

From this we may deduce:

1. A connexion of the marine beds of the Kachh Series with the upper portion of the Uitenhage formation in Africa, and with European Oolites at the same geological era, and

2. A connexion of the plant beds of the Jabalpúr Group and Kachh, through Dhagestan, Russia, with Europe, and on to Yorkshire at the same epoch.

3. A connexion of the Rajmahal Series in the Rajmahal Hills, passing Atgurh, with Golapili, also through North Persia with the Banat, Fünfkirchen, and the Alps on the north, and perhaps with the lower portion of the Uitenhage formation in South Africa.

4. That there was no connexion at this time with the Australian region.

II. *Fossils of the Lower Portion of the Gondwanas.*

To understand the age and relations of the lower part of the Gondwana rocks, we have again two groups to consider, known to Indian Geologists as the Panchet and the Damuda beds. From a palæontological point of view I consider both of these as of one epoch, and would include with the latter the Talchir Group, as of the same or nearly the same age.

a. FOSSILS OF THE PANCHET GROUP.

The vertebrate fossils have been described by Professor Huxley,[1] and on account of these the Panchet Group has been considered as probably Triassic.[2] The remains are principally *Dicynodon orientalis*, Huxl. (portion of a skull, tusks, vertebral extremities are known), and *Gonioglyptus longirostris*, Huxl. (portion of a skull, dermal plates, etc.).

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[1] Palæont. Indica, 1865 (4, 1).

[2] Oldham, Mem. Geol. Surv. India, vol. iii.

These fossils resemble very closely those Reptilian remains which Mr. F. Braun figured, 1846,[1] from the Upper Trias, near Bayreuth, Bavaria.

The plant remains establish the Triassic affinity still further, a prevalent species of *Schizoneura* (*Schizon. Gondwanensis*, Fstm.) being identical with that very abundant in the Damuda Series, and the best representative of the Trias, a *Tæniopteris* (near to *Tæniont. stenoneura*, Schenk), rather common *Pecopteris concinna*, Presl., and *Cyclopteris pachyrhachis*, Göpp., all being species found in Europe in the Upper Trias; so that I have attributed the Panchet Group to the age of the Keuper.

There are perhaps similar Reptilian remains in South Africa, establishing thus a connexion of the Panchets with the South African rocks.

From this it follows:

1. That the Panchet Group shows the closest connexion with Europe, both by its plants and other fossils—although it is not impossible that similar Reptilian animals lived a little earlier in South Africa and came from there over to Europe and India.
2. No connexion with Australia.

b. Fossils of the Damuda Group.

In this group plants only have been hitherto found, without any trace of a terrestrial or of a marine Fauna.

From the occurrence of the genus *Glossopteris*, Bgt., in these beds, they have been for a time brought into connexion with the Australian Coal-measures, and declared, without any further proof, as probably Palæozoic,[2] although the frequent presence of the Triassic genus *Schizoneura*, Schimp., has been noticed,[3] and also other plants, the only fossils in these beds that have been discovered, which evidently claimed Mesozoic age for our Damudas.[4]

This supposition of their Palæozoic age will not, however, explain the occurrence of the other and very frequent genera of Damuda plants, which do not occur in Australia at all, but have instead representatives in Europe, nor will it agree with the total absence in the Damudas of the animals which are said to be associated with *Glossopteris*, Bgt., in Australia.

Sir Charles Bunbury says, page 345, in his "Nagpúr Flora" (l.c.), referring to Dr. Oldham's paper (Mem. Geol. Surv. Ind., l.c.): "Prof. Oldham is of opinion that the Rajmahal beds are Mesozoic and probably Jurassic; the Damuda beds Palæozoic. On this latter point I am not entirely prepared to go along with him. I still think, for the reasons already given, that the facies of this Nagpúr and Burdwan Flora is rather Mesozoic."

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[1] Verzeichniss der zu Bayreuth befindlichen Petrefakte, 1840, p. 79, pl. viii. and foll.

[2] Dr. Oldham, Mem. Geol. Surv. Ind. vol. ii.; H. F. Blanford, Quart. Journ. Geol.-Soc. 1875; W. T. Blanford, Rec. Geol. Surv. India, vol. ix. No. 3.

[3] Dr. Oldham, l.c., pp. 327, 330.

[4] In 1871 Dr. Stoliczka brought some specimens from the Kurhurbari Coal-field, among them *Sagenopteris*, *Gangamopteris* (or *Cyclopteris* of that time), and three specimens of *Voltzia heterophylla*, Bgt. In 1873 Mr. Hughes brought from the Raniganj Coal-field some specimens, among these a Fern of the genus *Actinopteris*, which I described as *A. Bengalensis*, Fstm.

Dr. Oldham himself, as I said, has also recognized that the genus *Schizoneura* would suggest a Triassic age, but considered it not sufficient to establish the fact, which I think I can prove satisfactorily.

Sir C. Bunbury (*l.c.*) on the same page says further: "The palæobotanical evidence is far from unequivocal, and, such as it is, might be outweighed by the discovery of a single well-marked and thoroughly[1] characteristic fish, shell or coral." But none of these have been as yet found. On the contrary, many more plant remains have been discovered, which prove further Sir Ch. Bunbury's general view of their Mesozoic age, and particularly claim for our Damuda Series a lower Triassic age.

Not a single Carboniferous plant has been found, nor anything which for a moment justifies the supposition of the Carboniferous age (in the true sense) of this series;[2] this fact and also the Flora proves that there is no sudden break between the lower and upper group of the Gondwana Series, as from what has been previously written one might be led to suppose.

The only relation with the Australian Lower Coal-measures is through *Glossopteris*, Bgt., for which I will offer an explanation further on; while I do not know any real *Phyllotheca*, Bgt., from this portion, only from the Upper Coal-measures above the Fauna.

The Damuda Flora abounds in Equisetaceous plants, amongst which the Triassic genus *Schizoneura*,[3] Schimp. (*S. Gondwanensis*, Fstm.), identical with the same in the Panchet Group, most numerously prevailed, especially, it is true, in the Raniganj Coal-field, but known also in nearly the same abundance in the Nerbudda valley (Upper Denwa valley). It gives to the whole series a specially Triassic character, together with the others, while *Glossopteris* is subordinate. The genus *Phyllotheca*, Bgt., in its true form (as that from the Italian Oolite), is pretty frequent, but till now known mostly only from the neighbourhood of Nagpúr,[4] and in some specimens from the Raniganj field;[5] while the other specimen, which one generally designates *Phyllotheca* also, belongs mostly either as stalks or stems to *Schizoneura*, Schimp.

The true *Phyllotheca*, Bgt., in Australia is known mostly only from the Newcastle Coal-field, above the marine fauna, and from Mesozoic rocks, in Victoria,[6] together with *Tæniopteris Daintreei*,

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[1] This important word is left out in Mr. H. F. Blanford's paper, Quart. Journ. Geol. Soc., 1875, p. 525, while quoting this sentence from Sir C. Bunbury.

[2] There is therefore no reason for it, when Mr. W. T. Blanford, Rec. Geol. Surv. India, vol. ix. No. 3, p. 82, says, that the same Flora, which now should prove Trias, justified the assigning of a Palæozoic age to the Damuda formation (as did Dr. Oldham and Mr. H. F. Blanford, l.c.). The Flora was from the first beginning of its discovery the same Triassic Flora as to-day.

[3] Known for a long time.

[4] See Sir Ch. Bunbury, Quart. Journ. Geol. Soc. vol. xvii. Also our collections prove it.

[5] Only lately I have discovered it among our specimens.

[6] Report of Progress, Geol. Surv. of Victoria, 1874, p. 35.

M'Coy,[1] which also in Queensland[2] is taken as representative of the Mesozoic portion of the rocks. *Phyllotheca*, Bgt., however, is best developed in Europe in the Italian Oolite,[3] of which one form has all the generic characters; and nothing of this kind is known anywhere in Carboniferous strata.

Among the Ferns, if we omit for the moment the genus *Glossopteris*, they are throughout Mesozoic forms, such as *Macrotæniopteris Feddeni*, Fstm., very near to the *M. lata*, Oldh., Morr., of the Rajmahal Flora;[4] *Alethopteris Lindleyana*, Royle (belonging to the Mesozoic Group of *A. Whitbyensis*, Göpp., Schimp.); an *Angiopteridium*,[5] very near to *A. M'Clellandi*, O. M., from the Rajmahal Series; *Sagenopteris*, Bgt.;[6] *Gangamopteris*, M'Coy[7] (the latter from Mesozoic rocks in Victoria). Of special value and importance is a *Neuropteris*, with a single pinnate leaf, belonging to the Triassic Group of *Neuropteris* of the Vosges (I described it[8] as *Neuropteris valida*, Fstm.); also a typical *Actinopteris*[9] (*A. Bengalensis*, Fstm.) shows the Fern nature of this fossil.

Cycadeous plants are not absent at all;[10] on the contrary, Sir C. Bunbury's *Nöggerathia Hislopi* has its place here; and I determined besides this another *Nöggerathia* from the South Godavari District as very near, if not quite identical with the *Nöggerathia Vogesiaca*, Bronn,[11] and lately a *Glossozamites*, Schimp., several years since[12] in our collections, which I call at once *G. triassicus*, Fstm.

The Coniferæ are represented by *Voltzia heterophylla*, Bgt.; *V. acutifolia*, Bgt.; and *Albertia speciosa*, Schimp., of which the latter two, it is true, have been discovered only last year, but the former has been five years in our collections.[13]

About the Triassic nature of this Flora there can be very little doubt, and the occurrence of *Glossopteris*, Bgt., cannot alter the weight of evidence.

In the same manner as *Pterophyllum* began in the lower Permian, and has very near relations in our Rajmahal Hills (*Pteroph. Cottæanum* and *Pteroph. Carterianum*, Oldh.), as *Ptilophyllum*, Morr., survived from the Rajmahal Series to the Kachh Group, in the same way as *Schizoneura*, Schimp., survived from the Damudas to the Panchet Group; and as in the Salt range *Bellerophon* passes from the Carboniferous into the Trias, so *Glossopteris*, Bgt., passed from the

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[1] *Ibid.* p. 35.

[2] Daintree, Quart. Journ. Geol. Soc., vol. xxviii. p. 288.

[3] Zigno, Flora fossilis form. Oolithicæ.

[4] Some years ago brought by Mr. F. Fedden.

[5] Sir C. Bunbury's *Tæniopt. Danaeoides* (?), *loc. cit.* p. 332, pl. x. 2; other specimens a long time since in ours and the As. Society's collections.

[6] Some specimens from Kurhurbari brought by Dr. Stoliczka, 1871.

[7] Formerly known as *Cyclopteris*, Bgt.; many years in our collections.

[8] Rec. Geol. Surv. India, vol. ix. No. 3, p. 75.

[9] Described *ibid.*, brought 1873 by Mr. Hughes.

[10] Mr. W. T. Blanford, 1876, Rec. Geol. Surv. India, vol. xiii. No. 3, p. 82, is therefore not right in saying: "Cycads abound in the former, but have not hitherto been found in the latter (Damudas)." They were indeed known long ago!

[11] Bronn, N. Jahrb. f. Min. Geol. Pal., etc., 1858, p. 129, ff. pl. vi.

[12] Brought from Kurhurbari Coal-field, 1871, by Dr. Stoliczka.

[13] Brought by Dr. Stoliczka from Kurhurbari Coal-field.

Carboniferous in Australia into higher beds, and became a surviving form in our Triassic Damudas.

These are all facts, supported and proved by the fossils themselves, and not based on any speculative suppositions.

In Australia we find *Glossopteris* in the Upper Coal-measures also, without any trace of marine fossils, which proves also the surviving of this genus; but except *Phyllotheca*, no other of our Damuda plants is associated with it, even in this upper portion of the Australian Coal-measures.

Again, in Australia there is found in the lower beds also a genuine Lower Carboniferous Flora (*Lepidodendron*, *Cyclostigma*, *Rhacopteris* (*Sphenopteris*), etc.), while nothing of this sort is found in India.

It might therefore rather be supposed that there was no connexion at that time with Australia, where the beds were already deposited when *Glossopteris* immigrated into India at a time when this country was in connexion with the Triassic Europe during the deposition of the Damudas. Hence I may assert, concerning the Damuda beds, that:—

1. There is no great break between both portions of the Gondwana Series—both containing some related fossils, and the Panchet Group establishing very well the transition.
2. That no fossil from the Damudas will and can justify the supposition of a Palæozoic age; on the contrary, all the plant evidence tends to prove their Triassic age.
3. That Cycadeous plants are not wanting at all, as Mr. W. T. Blanford still lately said.[1]
4. That India was at the time, when the Damudas were deposited, in connexion with the lower Triassic European area, while *Glossopteris*, Bgt., survived from Australia, perhaps through China.
5. The supposition of a Palæozoic age of the Damudas on account of *Glossopteris*, Bgt., is not admissible, as all the other plants evidently contradict this, and as there are no animal fossils to prove the suggestion.
6. It is therefore a quite subjective supposition when Mr. W. T. Blanford[2] says that the evidence which connects the Damudas with the Australian Carboniferous rocks is about equal to that which tends to show their relations with the Trias of Europe.

When we consider all these facts, we are able to detect a wide connexion with India during the deposition of the Gondwana Series, but which plainly shows that the supposition of a connexion with Australia is a very weak one, as our Series represents the Juro-Triassic epoch, and not the Carboniferous.

1. *Glossopteris*, Bgt., grew first in Australia during the Carboniferous epoch, survived into India, passing perhaps through China, when our country at that time was in connexion with the European Triassic continent, which is distinctly proved by the fossils.
2. The connexion with Europe lasted till the time when the Rajmahal Flora grew, and this connexion was during the Liassic era.
3. During the Oolitic times India was continentally connected, from the Jabalpúr district through Kachh, Dhagestan, Russia, Middle Europe, etc., and so on to Yorkshire; at the same time the sea, which deposited the marine Kachh Beds and the Coconada Series, deposited also the South African Upper Uitenhage Group, and was in connexion some time previously with the European Oolitic Sea.

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[1] Records Geol. Surv. India, vol. ix. No. 3, p. 82.

[2] Records, vol. ix. No. 3, p. 84.

We have therefore as equivalents:

Upper portion of Gondwana Series = Jurassic	Middle Jurassic (Kachh—Jabalpúr Group). Liassic (Rajmahal Series).
Lower portion of the Gondwanas = Triassic	Keuper (Upper Trias) (Panchet Group). Lower Trias (Damudas and Talchirs).

Two short papers of mine upon this subject have been published the Records Geol. Surv. Ind. vol. ix. Nos. 2, 3; a third not yet ued will contain the Flora of the Jabalpúr Group, and some sup-ementary notes to my preceding papers.

My second paper is followed by one, written by Mr. W.T. Blanford, der a special title, but on the same subject. In this the author tends to revive once again the former views, which I trust are now more tenable, as I have shown sufficiently in this present short per.

Having himself seen my paper through the press, Mr. W. T. anford had of course the earliest opportunity of stating his views the subject in the same volume of the Records, before my paper s published.

In my present short paper I cannot enter into discussion of Mr. anford's views, and what I have to say against them will be stated detail in the next number of our Records.

I hope further examinations of the fossils, as the only guides determining the age of a Series, will contribute much towards earing up their relations, concerning which, however, I am already tisfied.

II.—SUBSIDENCE IN EAST ESSEX.[1]

By W. H. DALTON, F.G.S., of H.M. Geological Survey.

(Communicated with the Director's approval.)

HAT the latest movement of the south-east of England has been one of depression is evidenced by the numerous "submerged rests" which occur at intervals round the coast, ranging down-ards, not only to half-tide level, but to beyond the lowest ebb; and erefore not explicable merely on the hypothesis of sheltering sand-rs, or lines of dunes, even where such can be shown to have isted.

In East Essex, the question is complicated by the variety of possi-lities that have to be taken into consideration. The rapid waste of e cliffs at Harwich, Walton Naze, and Clacton sufficiently accounts r the disappearance of towns and villages mentioned in ancient cords as existing on that part of the coast, as they were almost in-riably erected on land above the sea-level, and therefore liable to attacked and destroyed by the sea.

Southward and westward from Clacton, deposition is still going on, and the "saltings," as the uninclosed land is termed, continually widen seaward, fresh strips being inclosed frequently.

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[1] Read before the Colchester Natural History Society, Oct. 5, 1876.

Though the surface of the saltings, covered with coarse grass and maritime plants, rises to the average level of high tides (owing partly to the retention by the vegetation of drifted organic and inorganic substances, and of silt suspended in the tidal waters), it is found on inclosure and drainage to sink about six or seven feet below the high-water level, the difference being due to the previous constant saturation.

These facts, coupled with the difficulty of ascertaining without elaborate observation the mean level of a sea so subject as the North Sea to be influenced by the set of the winds and the outline of the coast, render it necessary to observe very great caution in collecting evidence as to either elevation or subsidence within this area.

Without committing myself to the expression of a positive opinion, I wish to place on record certain facts and reports bearing on the subject which may be of use to future observers.

A bed of peat, resting on freshwater shell marl, occurs in the bed of the Orwell below Ipswich, 14 feet below low-water mark. (J. E. Taylor, Brit. Assoc. 1875.) A submerged forest with stools of trees in position of growth is said to occur in the Stour at Dovercourt.

In the alluvium of the foreshore in front of the town of Walton-on-the-Naze have been found fine specimens of *Cervus megaceros*, and other extinct mammalia. The old Bath House Hotel was originally erected about 30 yards nearer to the sea; its modern substitute is now beaten by the spray at spring tides, and the road in front of it occasionally flooded. This may be due either to a slipping seaward of the alluvium down an inclined plane of London Clay, or to such alteration of the slope as enables the water to run further up, or to real subsidence.

Between Clacton and St. Osyth, a submerged forest occurs on the foreshore. A legend, current in the neighbourhood, attests the former existence of a parish named Alton somewhere off the present coast-line thereabouts. A farm there is called Alton Park, but no mention is made of Alton by Morant or other historians. It may have been on a London Clay island or peninsula now destroyed. The forest, with elm stools still in place, forms the foreshore from beyond the lowest ebb-tide level up to a line of dunes which protect a low cliff of London Clay. The sea is attacking and removing the ancient soil, although deposition is going forward a few miles further west. This forest is probably of about the same age as the Walton alluvium, but on this point there is no positive evidence from either physical or palæontological sources. The space covered by it and the nature of the material (unctuous blue clay full of twigs and pieces of wood) forbid the supposition that the tree-stools have been let down from a higher level by the removal from below them of incoherent beds—a process which in the Stour estuary is depositing tree-stools in the position of growth on the alluvial flats below high-water mark.

The marsh land on the River Colne below Wyvenhoe is in some

›s below the low-water level of the river, and when flooded by nusually high tide requires to be drained by steam power. This be due partly to shrinkage as mentioned above (although the lows are constantly in a state approaching saturation), or it may ue to the deposition of mud in the bed of the river, consequent ıe supply of sewage from Colchester.

t the part of Colchester called the Hythe (*i.e.* Wharf) the Colne ıvigable at high water, and granaries, etc., constructed on its ts 200 years ago, are now frequently flooded in the basement by tides. Any slipping, such as I have suggested for Walton, is disproved by the existence of artesian wells extending deep the Chalk. An utterly imperceptible slip would certainly shear three-inch bore-hole.

ı a creek near Steeple, east of Maldon, a certain row of piles, the ›f which used 60 years ago to be just uncovered at high water, ıow covered about 18 inches deep at most tides.

n the south side of the Blackwater, the hills come down in a t to high-water mark at the old Roman and Saxon station of ›nia or Ithanceastre, the ruins of which are exposed on the beach. tidal slope is about a mile and a quarter wide, and on the r edge of this—an almost impassable bed of mud—there are r ruins, visible at dead low-water after storms have removed the and mud, and consisting of foundations, wells, etc., the arrange-t of which is perfectly plain at such times. Alluvium is being ›sited between these ruins and the main land, so that if it is se of denudation since the erection of the buildings, the currents t have altered considerably.

orth of the Crouch, the alluvium is 80 feet deep; on Fowlness westward it is about 30 or 40, indicating the existence of the ıch Valley at a time when the land was at least 40 feet above present level. Fowlness, a wholly alluvial island, has certainly ı stationary since the Norman Conquest, so that any movement ɔh may be in progress does not include that area.

III.—On the Motion of Glaciers.

By Rev. J. F. Blake, M.A., F.G.S.

a recent Number of the Geological Magazine[1] Mr. Burns assumes that Geologists in general seem to be satisfied with Mr. ll's theory of the motion of glaciers because they do not write in tation of it. I am convinced that with some at least it requires efutation, and its very obvious inadequacy is to them a sufficient on for passing it over in silence. There cannot be wanting men ›, appreciating the difficulty of the problem, can only smile at ı a "solution."

t seems absurd for one who has never seen a glacier in his life to e about their motion; and this has kept me silent on the point, ıgh I have given it some thought; but if it is the case, as Mr. Burns ›, that many geologists are contented with an erroneous theory, as it seems to me, it may be useful to clear the way for a true one, which may perhaps be done without a personal knowledge of glaciers. This paper is, therefore, rather critical of the theories of others, particularly of that of Mr. Croll, than suggestive of any of my own.

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[1] See Geol. Mag. 1876, Decade II. Vol. III. p. 297.

We have Mr. Croll's latest form of his theory extracted for us in the August Number of the GEOLOGICAL MAGAZINE, which we are to regard as alone representing it, although in his book, "Climate and Time," the original form in which it was criticized by Mr. Burns was allowed to stand as well, and was understood by me in the same sense as by the latter writer. But it is of very little consequence in which form it is stated, and I will examine the ideas derivable from the extract last given.

Mr. Croll says, "Ice is evidently not absolutely solid throughout. It is composed of crystalline particles, which, though in contact with one another, are, however, not packed together so as to occupy the least possible space, and, even though they were, the particles would not fit so closely together as to exclude interstices." In reading this we must be careful to obtain a right idea of the size of these interstices. The reference to Prof. Tyndall's explanation of the cause of the expansion of water in freezing—a very probable explanation—shows that they are interstices between single molecules, and therefore too small to be even microscopic. Although this structure of ice is said to be "evidently" the true one, it rests on no basis but Prof. Tyndall's theory; and therefore must be understood as he would understand it.

It might be thought by some that the question of interstices in ice would be connected with its origin; either as crystallizing directly from water, or formed by compression of snow crystals, as in a glacier; but this would have reference to interstices of quite a different magnitude, not at all molecular, though possibly microscopic. No—the interstices in Prof. Tyndall's theory must exist in the smallest possible crystal, in fact be in the essence of a crystal, and therefore *all* ice must as far as they are concerned act as glacier-ice.

If Mr. Croll does *not* mean molecular interstices, then of course the answer to his theory will be different; but then also his reference to Prof. Tyndall is in vain, and the supposed structure of ice by no means "evidently" the true one.

In the passage quoted by Mr. Croll, Prof. Tyndall clearly says, "The molecules turn and rearrange *themselves* (the italics are mine), demanding as they do so more space." It is the mutual relation of one molecule to another that is altered in solidification, and not any alteration in the shape or nature of a single molecule, which would be absurd; since by the definition of a molecule [which Mr. Croll does not appear to know] any such change would alter the substance from water to some other compound of its elements.

When, therefore, Mr. Croll in his next paragraph says, "when a crystalline molecule melts," he either uses the word "molecule" in a sense different to that of Prof. Tyndall and peculiar to himself, or confuses the true molecule, as defined in any book on chemistry or physics, with something much larger, equivalent in the popular mind with "a very little bit," and having no connexion with the molecules hat rearrange themselves in freezing.

A true "molecule" cannot be "crystalline," because you cannot arrange one thing except with respect to others. You might as well speak of a single soldier drawn up in a hollow square, and when the molecule "melts," of the soldier being disbanded.

When, therefore, Mr. Croll writes in this way, Prof. Tyndall and he part company, and it is difficult to know what sense to put upon what follows; with that one phrase of his the whole edifice falls.

Using, however, the word molecule in its proper sense, it may be worth while to follow a little what might possibly happen in the case supposed. Writing what Mr. Croll would express, in strict language, he may be supposed to say that, when, by the action of heat, several molecules adjacent to each other lose their polarity and the crystalline substance melts, some of these molecules will fit better into the spaces left between those still forming part of the crystalline substance, and better also among themselves, so that on the whole they occupy less room than before.[1] This, of course, is true. He then says that these molecules, on resolidifying, will not do so so as to fit the cavity which they occupied when in a fluid state. Taking this assertion as I have modified it, so as to represent what alone can be Mr. Croll's meaning, I think it cannot be upheld; but of that anon. I would examine his reasons. He says, "The liquid molecule in solidifying assumes the crystalline form, and of course there will be a definite proportion between the length, breadth, and thickness of the crystal; consequently it will always happen that the interstice in which it solidifies will be too narrow to contain it." Here, I must say, the confusion seems complete; for whatever definition we give of a molecule or an interstice, we are equally landed in difficulties. Mr. Croll's idea of a molecule, from this sentence, would seem to be a small portion of the substance which, when melted, may take any shape, but which, when solid, must take up a definite crystalline shape. Is this small portion of the substance divisible or indivisible under the ordinary forces of nature? If divisible, why should it not flow into several interstices and be squeezed into more still in the act of solidifying?—and Mr. Croll says it flows into the "interstices" (plural)—where it might make several *smaller* crystals than the original, according as there was room. If indivisible—and Mr. Croll further down speaks of "the interstice"—the main mass would remain in the original cavity, and by the hypothesis of indivisibility could only crystallize by coming back together, or by the main mass coming after the minute portion that had got entangled in an interstice. Mr. Croll seems to think the former could not be the case, as he says that in crystallizing "the molecule will press the two adjoining molecules aside in order to make sufficient room for itself between them, and this it will do, no matter what amount of space it may possess in all other directions.

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[1] This phraseology would have to be altered if we consider heat to consist of the *motion* of molecules, but I have kept as close to Mr. Croll's language as possible.

The crystal will not form to suit the cavity, the cavity must be made to contain the crystal." Here the idea appears to be that the main mass of the "molecule" is in *the* interstice, which would, of course, involve that ice should be only about half the density of water, unless we resort to the hypothesis of the interstices being of different sizes, or occurring every now and then, and the results happening only when the melted "molecule" happened to fall into a cavity large enough to nearly hold it all. But it is of no use to follow this further; the whole matter is founded in a confusion about what a molecule is, and such a molecule as Mr. Croll appears to conceive has never been yet heard of in physical science.

But going back to where we left off in strict language. Suppose a number of molecules were to be loosed from their crystalline arrangement by heat, and so occupy, on the whole, less space, on re-crystallizing what is there to prevent them going back to their own place again? Unless some new force is brought to play on the instant, whatever old forces they originally overcame in the act of crystallizing the first time, they can certainly overcome again. But what new force is brought into play? None that Mr. Croll mentions. Gravity always acted, and the molecular forces of crystallization are just as competent to push back the molecules against it as they were before when first the ice was formed.

It is to be observed that there is nothing in Mr. Croll's theory to distinguish a glacier from an ordinary piece of ice, and if one will flatten out as he supposes, the other ought to do so too. But who ever saw a block of ice bulge out under the influence of heat? If any one has ever seen such a thing, or has made any experiments upon it, it would be far more to the point than theory; or if these molecular changes could go on, even in a large mass of ice, without any *vis-a-tergo,* surely some tendency to a definite shape ought to have been observed in icebergs, which should, "as the mass widens out, grow thinner and thinner." If, therefore, we could substitute for Mr. Croll's theory, as explained by himself, some other, physically correct, embodying the same idea of molecular changes under the influence of heat, it would, even then, prove too much.

Hitherto I have assumed, with Mr. Croll, that heat acting on a mass of ice could produce these meltings and re-solidifying of small portions of it as distinct from those other surrounding portions, or rather that such changes might somehow be brought about, and have shown that they can have no such effect as supposed. But I now ask, What is the *real* result of heat acting on a mass of ice? Can there be such a thing as a small melted portion (I will no longer use the word "molecule" in a wrong sense) passing on its heat to "the next," by which means that becomes melted, and so passes on the heat again? It is certainly an ingenious idea, and one cannot help admiring its boldness; but then it has nothing whatever to do with the real state of the case when a solid body such as ice is subject to heat. We hear nothing of its latent heat, and of its conductivity—two of the essential elements of the question. Before a small mass, or, as we may call it, particle, of ice can melt, it must first be brought to melting point, and then so many units of heat must be supplied in addition to melt it. Suppose a melted particle in the midst of ice colder than at melting point, its heat would be distributed in raising the temperature of the surrounding ice, according to its conductivity, and what was left would be insufficient to melt any other particle of its own size. Hence, before the solidifying of one particle could be sufficient for melting another, the whole surrounding mass must be at melting point, and this, I believe, is not by any means the temperature of the interior of a glacier; and there must be some cause for the devotion of the spare heat to one particle alone, to say nothing of the cause which is to bring about a perpetual doing and undoing of the same operation. If there could be any such passing on of a melted state through a body to the other end, we ought to see a glass rod held in the fire melting at the end away from the fire, or does the outside particle refuse to melt? A candle, too, ought to melt in the socket instead of near the lighted wick, and to bulge out into abnormal obesity.

But what does happen when ice is subjected to heat on one side? First, the heated side is raised to melting point, while as we recede from that side the temperature gradually diminishes to its lowest point at the side we may suppose most remote from the source of heat. The temperature at any point between these two settles down to a fixed amount according to the temperatures of the two ends, the surrounding temperature of the whole, and the conductivity of the ice, and can only vary with one of these. The only variable elements of the four are the surrounding temperature, and the temperature of the other end, which are obviously connected together. The temperature of the hotter end (being the melting point of ice) and the conductivity may be considered for present purposes invariable. If more heat be now applied, it is spent in keeping up this state of the ice as to temperature against all possible losses and in melting that part of the ice that is nearest to it. No amount of this additional heat will alter the state of the interior—except so far as it may alter the *other* conditions on which it depends. However, if changes in the other conditions take place, the source of heat may be a long time bringing about this settled state of temperature, and during this time it will of course cause changes in the temperature of the interior. *But no amount of external heat could possibly bring about internal melting in a uniform mass of ice.* It is simply a myth. These statements of mine will be recognized by any physicist as a piece of elementary knowledge obtainable from most text-books on heat. I cannot think of anything that would explode the theory more effectually than these simple well-known facts.

But now it may be asked—How then does the glacier move? For it certainly moves particle by particle, for it alters its shape, and heat has some influence on it, because it moves faster in summer than in winter. In reply I may say that I think the true answer to this question must be made by one who has opportunities of making special observations on glaciers, so as to ascertain, with a view to the solution of the problem, the peculiar circumstances under which a glacier is placed, and the details of its motion. Knowing these things only at second-hand, it would be folly in me to pretend to give a solution, and I would only venture a few theoretical and reconstructive remarks.

Although the temperature of glacier-ice is not throughout as much as 32° Fahr., a considerable portion is doubtless not far removed from that, and we may perhaps conclude that motion only takes place in that which is within 1° of melting point. Perhaps some one acquainted with glaciers could answer this? Now it has been shown by careful experiment that it requires more units of heat to raise ice through the last degree of temperature before melting point than any other, which can be accounted for by supposing some of the heat to be taken up in preparing it to melt so to speak, in other words in beginning the alteration of its molecular arrangements so as to make the molecules more free to move upon each other. The settling down of the whole mass of ice into a temperature state in which this loosening of the molecules extended through some distance would be more easily accomplished in a glacier than in a smaller mass of ice, and in summer it would be more completely brought about than in winter. It is true that Prof. Moseley has performed experiments to show that ice, in order to separate, requires a shearing force of 70 lbs. per square inch, and that the loosening would have to be enormous to bring this within the power of gravity as exercised on an ordinary glacier; but every little helps. Another way in which the shearing force of glacier-ice may be reduced is by its containing a considerable quantity of air entangled within it. A very interesting article on this point was contributed by John Aitken to *Nature*, February 13, 1873, in which the writer details experiments showing that such ice will bend and change its shape under 6 lbs. or 7 lbs. pressure only per square inch; so that the nature and origin of the ice is obviously of considerable importance in the question.

I have myself tried similar experiments to those of Prof. Moseley, so arranged that considerable pressure was brought to bear on the surfaces to be sheared, and came to the conclusion that if you want to *see* the ice shear, as much force must be brought to bear as he has indicated; but the force required proved to be so considerably dependent on the time that I found it beyond my power to keep the ice at the same temperature and diameter long enough to reduce the necessary shearing force as low as I believed it might be reduced, if we gave it time to do its work slowly and imperceptibly, as in a glacier; and Mr. Miall has shown that substances whose shearing was greater than their breaking strain may yet be bent, *i.e.* sheared, by a comparatively small pressure long applied.

When we thus see how much the shearing force may be reduced by time and temperature, and take also into consideration the effect of alternate contraction and expansion with the variation of the external temperature, we shall have data enough out of which to construct a true theory of the motion of glaciers, without having recourse to

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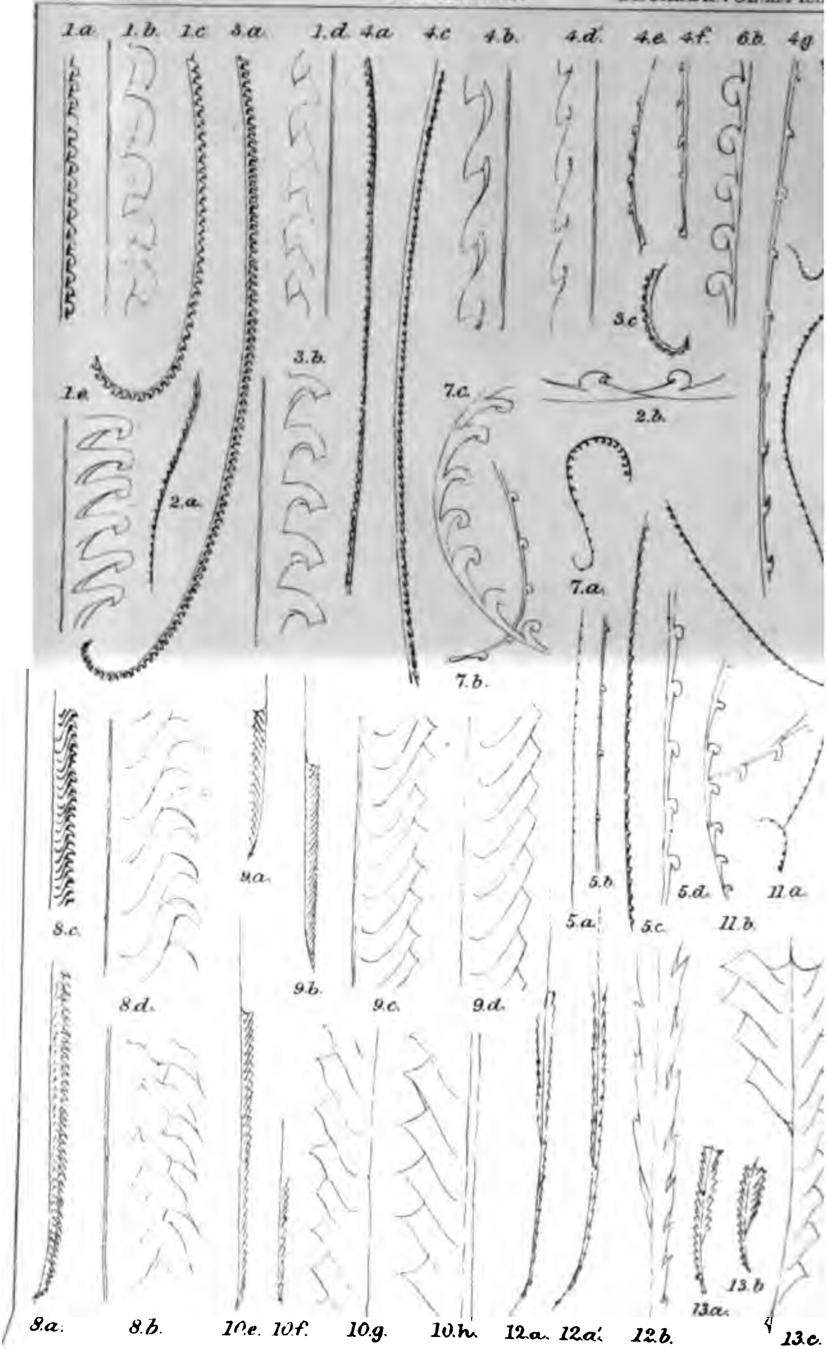

Chas. Lapworth del. et lith. W. West & C

Scottish Monograptidæ

imaginary meltings. Such a theory has not yet, I believe, been constructed, nor can I, of course, attempt to do it. Is it not rather, however, a question for the physicist than for the geologist? It is certain that glaciers *do* move, that they move in some respects like rivers, that they have a great grinding power, and that they can be driven up inclines; but the physical details of the cause of the motion, though in the highest degree interesting to the geologist, are, I think, a little beyond his province to determine.

IV.—On Scottish Monograptidæ.

By Charles Lapworth, F.G.S.

(*Continued from page* 360.)

(PLATE XX.)

§ VII.

Group 5.—Type, Monograptus lobiferus, M'Coy, sp.

Polypary usually slender and curved. Hydrothecæ in contact only; distal extremity of each either reflexed or coiled up into a rounded lobe.

26. Monograptus lobiferus, M'Coy, sp. Plate XX. Fig. 1.

Graptolithus lobiferus, M'Coy; British Palæozoic Fossils, pl. i. b. fig. 3. Nicholson, Quart. Journ. Geol. Soc. vol. xxiv. pl. xix. fig. 30.

Graptolithus millepedia, M'Coy; ibid. fig. 6. Geinitz, Die Graptolithen, Taf. iii. figs. 33, 34; Taf. iv. fig. 5.

Graptolithus Becki, Harkness; Quart. Journ. Geol. Soc. vol. vii. pl. i. fig. 5. Geinitz, op. cit. Taf. iii. fig. 14.

Graptolithus Nicoli, Harkness; Quart. Journ. Geol. Soc. vol. vii. pl. i. fig. 6.

Graptolithus priodon, Richter; Zeitschrift d. Deutsch. Gesellsch. 1853, Taf. xii. fig. 22.

Diplograpsus nodosus, Harkness, loc. cit. figs. 10*a*—10*b*.

Polypary slender, several inches in length, distal portion straight, proximal portion sharply recurved. Hydrothecæ 20 to 25 to the inch, in contact at their bases only; narrowing in the direction of the apertural portion, which is curled up into a rounded lobe.

The proximal or recurved portion of the polypary is comparatively short, rarely exceeding three-fourths of an inch in length. Distally it is either perfectly straight, or has a very gentle dorsal curvature. The fully developed polypary must have been of extraordinary length, as straight fragments of more than a foot in extent are by no means rare.

The hydrothecæ are subtriangular in form, and—exception being made of their peculiar terminal curvature—they agree precisely in their form and disposition with those of *Monograptus convolutus*, His. They rise perpendicularly from the convex margin of the periderm, and their bases, which just touch each other at their extremities, have a length which is the same as, or but slightly less than, that of the theca itself. The terminal portion of the latter is bent abruptly backwards in the direction of the proximal extremity of the polypary, its inferior margin pressing against the central portion of the theca, or even slightly transgressing upon its surface. This is the origin of the remarkable thecal lobe which constitutes the chief characteristic of the whole group. The external orifice is brought round in this way so as to open in the direction of a point on the ventral margin of the polypary, lying a little on the proximal or first-formed side of the base of its own hydrotheca. The apertural margin is quite straight, and is usually wholly devoid of ornament.

The number of hydrothecæ to the inch is far from constant, and there are at least three prime distinctions in their shape and proportion. In what may be regarded as the typical form of the species (Figs. 1 *a*, *b*), they undergo scarcely any contraction distally, and the lobe is consequently large and ball-like. In the commonest variety (*M. Nicoli*, Hark.?) they are short and pointed, and specimens occasionally occur almost inseparable from extreme forms of *M. convolutus* (*communis*); while in a second variety (= *millepedia*, M'Coy) they are long and tubular, and the lobe is scarcely distinguishable.

Locality.—Very common in the middle and higher beds of the Birkhill Shales at Belcraig, Glenkiln, Garple, Dobbs Linn, Craigierig, etc.

27. MONOGRAPTUS BECKI, Barrande, sp. Plate XX. Fig. 2.

Graptolithus Becki, Barrande; Grapt. de Bohème, pl. iii. figs. 14 to 18.

Monograpsus Becki, Geinitz; Die Graptolithen, Taf. iii. fig. 13.

Polypary long and narrow, straight (?), or with a slight ventral curvature. Hydrothecæ 20 to 25 to the inch, free, either wholly or in part, outer extremity of each forming a rounded lobe.

In the preceding species the early hydrothecæ resemble those on the fully developed portion of the polypary in everything but size. Here, on the contrary, they are distant, long, and linear, with their apices only slightly reflexed; while the later ones are closely set, are subtriangular in form, and have nodose terminations. Again, the former are pressed flat against the ventral margin, and only a very small fraction of their length is isolated; while the bases of the latter are in contact, and they are free and isolated throughout the whole of their extent. That portion of the polypary which carries these less developed thecæ is often a couple of inches in length. In the Birkhill examples it forms a gentle and continuous curve, the thecæ being disposed upon its concave margin. In the much more recent specimens afforded by the shales of the Gala Group, the first half-inch is bent slightly backwards, and examples now and then occur in the transition beds which are almost straight.

In this species we very frequently meet with those examples in which the sicula, at the same time that it throws off the normal series of hydrothecæ in the usual manner from one of its lateral margins, also gives origin to a second series, which is developed in a direction exactly opposite. The two primary hydrothecæ are symmetrically united to each other by their lateral faces, and are so similar in their external features that it is impossible to say which was the fundamental germ. These monstrosities occur in association with forms in which the sicula throws off a single series only. Figures illustrative of this remarkable deviation from the normal mode of development (which occasionally occurs also in *M. runcinatus* and *M. tenuis*) are given on Plate XX.

The typical example of this species figured by Barrande is the Gala form mentioned above, in which the proximal extremity has a slight double curvature.

Locality.—Common in the highest beds of the Birkhill Shales at Birkhill, March Burn, Eldinhope, River Ettrick, etc.; and in the Gala Group at Meigle, Cascade, Caddonfoot.

28. MONOGRAPTUS CLINGANI, Carr., sp. Plate XX. Fig. 3.

Graptolithus lobiferus, Nicholson; Quart. Journ. Geol. Soc. vol. xxiv. plate xix. fig. 29.

Graptolithus Clingani, Carruthers; GEOL. MAG. Vol. V. Plate V. Fig. 19.

Polypary long and narrow, distal portion almost straight; proximal extremity recurved. Hydrothecæ 25 to 30 to the inch, in contact at their base only, subtriangular in form, contracting in the direction of the aperture, which is bent round so as to face the proximal extremity of the polypary.

The hydrothecæ are similar in form along the whole of the length of the polypary. Each is a minute triangle, of which the base is almost equal to the height. The distal portion is prolonged, and the external orifice is comparatively narrow. The former is bent backwards at right angles to the axis of the theca, and the latter opens in the direction of the proximal extremity of the polypary, parallel with the general line of its polypiferous margin.

Young examples occur in great abundance, and it was upon these that the species was founded. The adult form is rare, and has only recently been distinctly identified.

M. Clingani is a very unsatisfactory species. It may best be regarded as lying between *M. convolutus* (*communis*) and *M. lobiferus*. From the former it is separated by the abrupt reflexion of the terminal portion of its hydrothecæ, and from the latter by the absence of a distinct rounded lobe.

Locality.—Common in a single zone in the higher portion of the Birkhill Shales at Dobbs Linn, Moory Syke, Whitehope Burn, etc.

29. MONOGRAPTUS RUNCINATUS, sp. nov. Plate XX. Fig. 4.

Polypary several inches in length, narrow and gently curved throughout. Hydrothecæ 24 to 28 to the inch, narrow tubes expanding slightly in the direction of the aperture; proximal half of each appressed to the concave margin of the periderm, distal portion free and abruptly reflexed, the aperture being directed obliquely inwards; denticle acuminate, conspicuous.

The form of the polypary is very similar to that of *Monograptus Becki*, and the early hydrothecæ in both species are almost identical.

In the fully developed portion of the polypary, however, they are strikingly different. In the present species each theca is a narrow tube, which augments its diameter as it increases in length. For about half its extent it is pressed flat against the periderm—so closely that the line of separation is usually invisible, even in specimens preserved with their full relief. The distal half, on the contrary, springs suddenly outwards, almost at right angles with the axis of the polypary, and is at once doubled back upon itself, in such a manner that its free inferior margin is forced round into contact with that of the attached portion. The edge of the aperture is very oblique, making an angle of 150° with the axis of the polypary.

The denticle formed by the direct edge of the aperture and the curved superior margin is acute, and frequently causes the species to be confounded with some varieties of *M. convolutus.*

At first sight of a well-preserved fragment from the fully developed portion of the polypary, it is impossible to avoid inverting it, and regarding the hydrothecæ as similar in their form and disposition to those of *Monogr. argutus.* This view is especially fortified by the peculiar and apparently unbroken curve of the outer margin of the theca, and by the non-visibility of any line of separation between the theca and periderm; but that our interpretation of these appearances is the correct one is placed beyond dispute, not only by the relations which exist between the direction of the free part of the theca, and that of the slender proximal part of the polypary in all complete normally developed examples, but also by the circumstance that in all bi-lateral specimens (which are abundant in some localities), the apertural portion of each theca in both polyparies is directed backwards upon their common point of origin in the sicula.

The nearest ally of the species is *Monogr. Becki,* from which it is separated chiefly by the characters of the distal hydrothecæ.

Locality.—Common in the highest beds of the Birkhill Shales at Mount Benger, Eldinhope, Dobbs Linn and Glenkiln.

30. MONOGRAPTUS BARRANDEI, Suess. sp. Plate XX. Fig. 5.

Graptolithus Barrandei, Suess; Böhmische Graptolithen, Taf. ix. figs. 12*a*–*b*.

Polypary about six inches in length, slender and very slightly curved. Hydrothecæ 16 to the inch, long and linear, appressed to the concave margin of the periderm for more than five-sixths of their length, distal extremity reflexed, and usually forming a small rounded lobe.

The proximal portion of the polypary—which may be regarded as embracing the first two inches of length—is of remarkable tenuity, and the periderm is little more than a mere line throughout. The curvature of the polypary is scarcely perceptible in this earlier portion. The hydrothecæ are narrower than in any of the other forms of the group, and the reflexed fraction proportionately shorter. It is never more than one-sixth of the length of the theca, and occasionally less than one-eighth. The characteristic lobe-like termination is formed only in the fully developed part of the polypary; the apertural portions of the early hydrothecæ scarcely project at all above the ventral margin, while the aperture is slightly everted, and there is a minute and very conspicuous denticle.

M. Barrandei was founded by Suess upon a proximal fragment possessing the characters noted above; but judging from his guarded reference to *Rastrites gemmatus*, Barr., as being merely one of its varieties, it is probable that he was aware of the occasional lobe-like form of its distal hydrothecæ. He regarded it as a species uniting the characters of the proximal portion of *Monograptus proteus*, Barr., and those of a true *Rastrites* (a genus he refused to recognize), believing that the distal projections made up the whole body of the hydrothecæ, which were thus isolated and separated from each other by long and barren internodes.[1]

Locality.—Very rare in the Gala Group at Buckholm, Meigle, and Grieston.

31. Monograptus exiguus, Nicholson, sp. Plate XX. Fig. 6.

Graptolithus lobiferus, var. *exiguus*, Nicholson; Quart. Journ. Geol. Soc. vol. xxiv. pl. xix. figs. 27 and 28.

Graptolithus plumosus, Baily; Mem. Geol. Surv. Ireland, Explan. Sheets 49, 50, p. 23, figs. 1*a*—*b c*

Polypary about one inch in length, slender, with incurved proximal extremity. Hydrothecæ 35 to 40 to the inch, proximal portion adnate to the periderm, distal portion isolated, and forming a small rounded lobe.

The periderm in this very distinct little species is a mere line, and the breadth of the whole polypary, inclusive of the projection of the hydrothecæ, is less than one-fortieth of an inch. The incurved proximal portion embraces about one-fifth of the total length, which never amounts to more than an inch and a half. The hydrothecæ are almost identical in shape with those in *M. Becki*, but the lobes are a little larger proportionally.

The size and shape of the polypary and its minute closely-set hydrothecæ effectually distinguish *M. exiguus* from all its congeners.

Mr. Baily gives an excellent figure of this species (*loc. cit. supra*).

Locality.—*M. exiguus* occurs in great profusion in the beds of the Gala Group at Caddonfoot, Meigle, Glendearg, Grieston, Douglas near Tushielaw, Glenkiln, etc.

32. Monograptus crispus, sp. nov. Plate XX. Fig. 7.

Polypary extremely slender, less than one inch in length; proximal portion almost straight, distal portion incurved. Hydrothecæ 20 to 30 to the inch, in proximal portion adnate, in distal portion free for half their length; outer extremity of each inrolled in a minute lobe.

The general form of the polypary in this species is strikingly characteristic. For the first tenth of an inch it is bent backwards, so that the earlier hydrothecæ lie upon the convex margin of the periderm. The following half-inch is perpendicular and slightly arcuate, and the final portion forms a complete semicircle which carries the hydrothecæ upon its inner edge.

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[1] Suess, Böhmische Graptolithen, s. 126.

In the first half of the polypary the thecæ are identical in form with those on the fully developed portion of *M. Barrandei.* Only one-eighth of the length of each is isolated, and that is curved into the ball-like final characteristic of the group. Those on the semicircular portion of the polypary are isolated for nearly half their length, and the lobe is longer and much more conspicuous.

Locality.—Rare in the Gala Group at Meigle, Buckholm, Gala Hill, Grieston, Cauldshiels, etc.

SUPPLEMENTARY SPECIES.

The three following forms are here noticed out of their proper order, owing to the want of sufficient material for complete diagnoses at the time their allies were described. The necessary specimens have since been collected by myself from the South Scottish Silurians. They all belong to the *Halli* group, but the third points in the direction of that typified by *Monograptus Hisingeri.*

33. MONOGRAPTUS FLEMINGII, Salter, sp. Plate XX. Fig. 8.

Graptolites Flemingii, Salter; Quart Journ. Geol. Soc. vol. viii. pl. vii. figs. 5 *a*—*h*.

Polypary straight and rigid, five or six inches in length, and with an average diameter of one-tenth of an inch. Hydrothecæ short and stout, 30 to 36 to the inch, overlapping each other for half their length; apertural margin convex, everted and produced in a long acuminate and very oblique denticle.

The sicula in this form is about one-twelfth of an inch in length, and together with the attached portion of the periderm is bent a little backward. There is often a short slender radicular process visible in the line of proximal prolongation of the adherent margin of the sicula.

The polypary gains its normal width within the first four inches, and for the remainder of its extent it rarely undergoes any further alteration in diameter.

The hydrothecæ, which are far more closely arranged than in any other species of the *Halli* group, are short tubes slightly contracting distally, and about four times longer than wide. They are in close contact throughout. Near the distal end there is a sudden expansion, and the terminal orifice is usually more than twice as broad as the body of the hydrotheca. The edge of the aperture is convex; the denticle pointed, and a very minute apertural spine is occasionally visible. In the earlier portion of the polypary the denticle is remarkably oblique, frequently making an angle of 150° with the ventral margin. As the polypary increases in length, the obliquity of the denticles gradually diminishes, so that fragments of more than four inches in extent have their final denticles almost horizontal.

The apparently excessive obliquity of the denticle is due to the peculiar form and great diameter of the thecal aperture. As in *M. Halli* and *M. Riccartonensis,* in the earlier thecæ the whole extent of the aperture is exposed to view. Its upper and nearest edge is undistinguishable in the fossil from the body of the hydrothecæ, upon which it is crushed down; while the long rounded margin which is the more distant from the observer, forms the visible distal boundary of the theca. In specimens preserved in strict profile, or with their full relief, the nearer margin of the aperture is visible and the obliquity is always much less. The proximal boundary of the denticle is formed by the expanded part of the theca immediately preceding the aperture.

According to Mr. Salter the orifice is situate on the lower or inferior side of the denticle, and the latter "overhangs the wide concave margin of the mouth, which abuts at its lower edge directly against the succeeding cell." In this view he was strengthened by Barrande's reading of the characters of his *M. chimera*, in which the relations of theca and denticle are similarly interpreted. A glance at Mr. Salter's figures is sufficient to prove that this view is wholly erroneous.

M. Flemingii is intimately allied to *M. Halli* and *M. Riccartonensis*. From the former it differs in the number and character of the hydrothecæ, and from the latter in the form and size of the theca and polypary.

Locality.—Common in the Riccarton beds at Riccarton, Shankenshiels, Balmae, etc.

34. MONOGRAPTUS COLONUS, Barrande. Plate XX. Fig. 9.

> *Graptolithus colonus*, Barrande; Grapt. de Bohême, pl. ii. figs. 1, 2, 3. Geinitz, Die Graptolithen, Taf. ii. figs. 33 to 36. Nicholson, Quart. Journ. Geol. Soc., vol. xxiv. pl. xx. figs. 9, 10, 11.

Polypary rarely exceeding a couple of inches in length, straight, rigid; rapidly expanding to a maximum width of one-tenth of an inch. Virgula distally prolonged. Hydrothecæ 24 to 28 to the inch, inclined at an angle of about 30°, contracting slightly in the direction of the aperture, the margin of which is oblique, concave and ornamented with a minute spine.

This species is remarkable among those of the *Halli* group in the shortness of the polypary and in the constancy with which the virgula is distally prolonged. The length of this extension varies from one-half to more than the whole of that of the polypary itself, and communicates a very distinctive aspect to the species.

The dorsal margin of the polypary is straight, except at its proximal end, where the small portion carrying the sicula and the first four or five hydrothecæ is usually bent a little inwards. The sicula itself is always very conspicuous, and the polypary springs out almost immediately to its full diameter.

The hydrothecæ differ slightly in appearance according to the variation in the direction and amount of compression. Each is a narrow tube, of which the length is about five times the width—with lateral margins either straight, or having the slight and elegant double curvature of the majority of the species of the *Halli* group. There is an apparent diminution in width in the direction of the aperture, which is placed at right angles with the axis of the theca. It is a little concave, and its outer angle forms a slight denticle, which is prolonged in a short and slender spine lying in the same plane as the orifice itself.

From *M. Galaensis* this species is effectually separated by the form and size of the polypary, the prolongation of the virgula and the details of the hydrothecæ. From the variety next to be described it differs chiefly in the form of the hydrothecæ and in their amount of overlap.

Locality.—Rare in the Riccarton Beds at Elliotsfield, Shankend, and Riccarton.

VAR. DUBIUS, Suess. Plate XX. Fig. 10.

Graptolithus colonus, Barrande; Graptolites de Bohème, pl. iv. fig. 5.

Graptolithus dubius, Suess; Böhmische Graptolithen, Taf. ix. fig. 5 *a*, 5 *b*.

Polypary straight and rigid, four or five inches in length, and with a maximum diameter of one-twelfth of an inch. Virgula distally prolonged. Hydrothecæ 20 to 25 to the inch, inclined at an angle of from 30° to 40°, in contact for less than one half of their length; short and broad tubes expanding slightly in the direction of the aperture, the margin of which is concave, oblique, and bears a minute spine.

In the young state the polypary in this variety closely resembles that of *M. colonus* in size and shape. Adult examples are comparatively narrower, and the maximum diameter is attained very slowly. The chief peculiarities of the variety are afforded by the character of the hydrothecæ. Each is a stout tube, of which the length is about twice the transverse diameter. In some views there is a fallacious appearance of contraction in the direction of the aperture, but all well-preserved specimens show the peculiar expansion in the central portion of the thecæ common to many forms of the *Hisingeri* group. When flattened obliquely, the edge of the aperture is seen to transgress for a great distance upon the body of the periderm, so that the orifice must have been very broad. There is a blunt denticle, which is sometimes ornamented with a minute spine.

Prof. Suess' original example seems to have been in a very poor state of preservation. He figures and describes it in an inverted position, believing the distal extension of the virgula to be radicular.

Locality.—Common in the higher zones of the Riccarton Beds at Riccarton and Hindhope.

EXPLANATION OF PLATE XX.

FIGS.

1 *a*—*e* *Monograptus lobiferus*, M'Coy, typical form. 1 *a*. *b*. distal portion; 1 *c*. *d*. var. *Nicoli*, Hark., proximal end; 1 *e*. var. *millepedia*, M'Coy. Dobbs Linn.

2 *a*—*b* *Monograptus Becki*, Barrande. 2 *a*. proximal extremity of the more recent form. Meigle Quarry. 2 *b*. central portion of broad bilateral example, magn. Frenchland Burn.

3 *a*—*c* *Monograptus Clingani*, Carr. 3 *a*. *b*. adult example. 3 *c*. young form. Dobbs Linn.

4 *a—g* ***Monograptus runcinatus***, Lapw. 4 *a. b.* central portion of bilateral specimen. Mount Benger. 4 *c. d.* fully developed fragment. Glenkiln. 4 *e.* young example showing normal mode of development. 4 *f.* ditto, with modified sicula. 4 *g.* initial portion of bilateral specimen. Mount Benger.

5 *a—d* ***Monograptus Barrandei***, Suess. 5 *a.* 5 *b.* proximal; 5 *c.* 5 *d.* distal portion. Buckholm.

6 *a—b* ***Monograptus exiguus***, Nich. 6 *a. b.* full-grown example. Caddonfoot.

7 *a—c* ***Monograptus crispus***, Lapw. 7 *a.* complete polypary; 7 *b.* proximal; 7 *c.* distal portion. Meigle Hill.

8 *a—d* ***Monograptus Flemingii***, Salter. 8 *a. b.* proximal; 8 *c. d.* distal fragment. Riccarton.

9 *a—d* ***Monograptus colonus***, Barrande. 9 *a.—d.* typical form. Elliotsfield.

10 *e—g* Var. *dubius*, Suess. Riccarton.

11 *a—b* *Cyrtograptus Grayiæ*, Lapw. 11 *a.* nat. size; 11 *b.* magn. Penwhapple Glen. (Coll. Mrs. W. Gray.)

12 *a—c* *Dimorphograptus elongatus*, Lapw. 12 *a.* nat. size; 12 *b.* magn. Dobbs Linn.

13 *a—d* *Dimorphograptus Swanstoni*, Lapw. 13 *a. b.* nat. size; 13 *c. d.* magn. Coal-pit Bay. (Coll. Wm. Swanston, Esq.)

REVIEWS.

I.—CATALOGUE OF THE WESTERN SCOTTISH FOSSILS. Compiled by JAMES ARMSTRONG, JOHN YOUNG, F.G.S., and DAVID ROBERTSON, F.G.S. WITH AN INTRODUCTION ON THE GEOLOGY AND PALÆONTOLOGY OF THE DISTRICT. By Prof. YOUNG, M.D. (Glasgow, 1876.)

ONE result arising from the peripatetic nature of the meetings of the British Association is the publication of handy guide-books of the antiquities and natural history of the district around the various places visited, such as those prepared for Bristol and Belfast, and, this year, for Glasgow,—in each case by the energy and exertions of the local scientific men, and by the liberality of the Local Committees of the cities visited. The guide-book for Glasgow has been arranged in three separate volumes, viz. the antiquities, the zoology and botany, and the geology, which latter forms the subject of our notice.

Under the modest title of a Catalogue of Western Scottish Fossils, the authors have given a vast amount of information on the geological structure of the West of Scotland, concisely treated, with numerous bibliographical references, and copious lists of localities from which fossils may be obtained, so as to form a really useful hand-book to the geology of the district.

Already Messrs. Armstrong and Young had published in 1871 a catalogue of the Carboniferous fossils, and Mr. D. Robertson his list of the fauna of the Glacial period, which may be said to form the nucleus of the present work, in which the information is brought down to the present time, by newly prepared lists of the fossils obtained from all the deposits, from the Silurian to the Glacial included,—no light task, considering the limited time at their disposal, and the evident amount of labour and care which they have bestowed on the preparation.

Not only, however, have the editors drawn largely from their own labours, but they gracefully acknowledge the readiness with which many friends undertook every trouble by which the work of compilation might be lightened, and fullness and accuracy secured. Among these, may be specially mentioned Mr. C. Lapworth (whose contributions to the GEOLOGICAL MAGAZINE are well known), who has not only written the summary of Silurian stratigraphy, but enhanced the value of the volume by the addition of four plates of Graptolites, and a table (p. 2) showing his view of the relation of the Silurian rocks of the eastern districts with those of Lanark, Ayrshire, and their English equivalents.[1]

The introduction by Prof. John Young is a useful summary of the Geology and Palæontology of the West of Scotland, and is an attempt to translate into history the geological details of the district, although the writer feels it contains some views not likely to receive general acceptance. Mr. John Young has prepared the preliminary sketches of the Old Red and Carboniferous formations, and the notes on the distribution of Carboniferous fossils; Dr. Bryce has written the notice of the Jurassic strata of Raasay and Skye; and Mr. Robertson the chapter on the post-Tertiary deposits and their contained fossils. Mr. Armstrong has compiled the chief lists of fossils, which together amount to about 2000 species. Of these, 350 are Silurian, including 100 Graptolites, 6 Devonian, 866 Carboniferous, 325 Jurassic, 12 Tertiary, and 436 post-Tertiary species. Mr. Armstrong has, further, superintended the general revision of the work.

The work is well printed, and will be a valuable addition to geological literature, as affording a compendium of the geology, as well as of the minerals, rocks, and fossils of Western Scotland, and fully justifies the remark in the preface—that the Local Executive Committee deserve the thanks of all students of science for the wise liberality with which they have entered on this publication, and thus secured what private means could not have easily accomplished—a record of Scottish Geology and Palæontology, which will be a permanent memorial of the Glasgow Meeting of the British Association for 1876.

II.—"THE PHYSICAL GEOGRAPHY OF THE GREAT INDIAN DESERT."[2]

GLACIATION now-a-days absorbs so much research that we seldom have opportunities of noticing efforts to trace the connexion between an existing state of things and that which immediately preceded, in countries where there is no room for glacial speculation—at least with regard to their later geological conditions. Mr. Blanford's paper, besides its novelty in this respect, is a valuable record of observation, though its geological interest might escape attention amongst the diversity of subjects to which the Asiatic Society of Bengal devotes itself.

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[1] On the classification of these rocks the reader might further consult the memoirs of the Geological Survey of Scotland, and a paper by Mr. J. D. Brown in Trans. Edin. Geol. Soc., vol. ii. pp. 227, 316 and 377.

[2] On the Physical Geography of the Great Indian Desert, with special reference to the former existence of the sea in the Indus Valley, and on the origin and mode of formation of the Sand-hills. By W. T. Blanford, F.R.S., Asiatic Soc. Bengal, vol. xlv. pt. ii. 1876.

Two subjects come into consideration in dealing with the Physical Geography of the Indian Desert—the zoology of the region and its recent geological history. Mr. Blanford adduces the connexion between the zoology of India and the fauna of Africa and the Mascarine islands in support of the idea that India formed part of a great tropical continent. An even more extended connexion is further mentioned as having characterized the life of the upper Palæozoic (?), Mesozoic, Tertiary and later periods; identical species amongst the flora of these earlier and Secondary times having been found in Australia, Southern Africa, and India (to which might have been added England, Dhagistan, and China)—while there have been three distinct Tertiary migrations into India of animals having African affinities; two groups of these having been earlier immigrants than the other.

Another circumstance noticed is that the peninsular region of India presents no similarity in a geological point of view with the Himalayan tract, or the countries west of the Indus or east of the Bay of Bengal. To this there is, however, one exception in the occurrence of some Damuda rocks on the flanks of the Eastern Himalaya. How far the observation may coincide with any supposed continental extension of India in Secondary times, when similar species of plants grew over so large an area of the eastern hemisphere, is scarcely apparent. But perhaps the author would not carry the continental conditions so far back upon the evidence of the plants, and may advocate these conditions for a more recent period only, but still the identity of forms in the fossil flora of Peninsular India, South Africa, China, Australia, etc., seems opposed to the utter geological isolation of Peninsular India pointed out.

With reference to this Peninsular region, it is also stated that, "wherever remains of sedimentary beds are found" "of any age from the dawn of life to the present day, they consist with but few and local exceptions of rocks which have been formed in all probability on the surface of the land." This appears at first a rather strong statement, but contains within itself a qualifying allusion to the fact that large formations among the older sedimentary rocks of Peninsular India are unfossiliferous. Ere this, Mr. Blanford has successfully contended for the sub-aërial origin of the "Deccan Traps," though the mode of their extension over thousands of square miles as horizontally bedded igneous rocks in local sheets unconnected with volcanic cones, has never been explained; but it is an entirely new idea that so much of the sedimentary rocks of the Peninsula of India as the passage quoted would seem to say have also been formed *on land*.

Being somewhat outside the subject of the paper, or remotely connected, it is not stated by what agency the beds have been deposited —whether by rivers, or land-locked or inland waters other than the sea. If the supposed continental conditions are relied upon here, the author would antedate them further than we thought at first.

The existence of Marine Cretaceous rocks at widely separated intervals, near or distant from the coast, is among the local exceptions admitted, and in view of the great terrestrial changes advocated, the fact would seem strong enough to sustain a doubt as to the other sedimentary formations, which contain no fossil evidence to the contrary, having been deposited on land.

Turning to the more local subject of the paper,—after describing at some length the physical characters of the Desert, its Zoology and Botany, the author notices the occurrence of depressions in the surface of the Desert, and among its sand-hills, usually filled after rain, and sometimes permanently with brackish, saline, or salt water. The ground being itself salt accounts for the saltness of most of these *dhands* or pools. Of two highly saline localities referred to, one, the furthest from the sea, appears to be the Panchpadder, an interesting account of which, and its 700 salterns, was given by Sir Alexander Burnes in an early volume of the Bengal Asiatic Society's Journal,[1] the soil although far inland being clearly indicated as the source of the brine. The other locality is near the river Narra, or old eastern arm of the Indus Delta, said to have discharged itself through the Runn of Kutch and the Koree estuary near Lukput, before the great earthquake of 1819. In some of the *dhands* near the Narra, Mr. Blanford found living a marine Mollusc—*Potamides* (*Pirinella*) *Layardi*, H. Ad.—precisely like the same species living now on the coast of India. The conclusion arrived at is, that this Mollusc must have inhabited the tract now occupied by sand-hills and *dhands* when this was in direct communication with the sea, and that the saltness of the soil of the country is due to its having been the bed of the sea or of an inlet, the sand-hills themselves having been formed on the margin of the inlet or lagoon, which was probably partly filled up by accumulations of blown sand. Further argument for the presence of the sea over this country is drawn from the condition of the Runn of Kutch lying about 100 miles to the southward.

In the Geological Survey of India Memoir upon the Kutch district (vol. ix. part 1) the water-worn, probably sea-worn, form of some of the islet shores of the Runn, and traditions as to its having in former times been navigable, are mentioned to support the inference that it was once submerged and afterwards slightly elevated (of course together with adjacent regions). This submergence would probably have admitted the sea to the valley of the Lúni river, whence it is thought part of the salt of the Runn is derived, and near the upper part of which Panchpadder is situated. With regard to the sand-hills of the Desert, Mr. Blanford cannot agree with Sir Bartle Frere that they may be due to earthquake action! Those lying at right angles to the course of the prevalent winds are accounted for in the same way as the small ripple-marks commonly observable upon the surfaces of blown sand; but others, the longest direction of which *coincides* with that of the prevailing winds, present more difficulty. Three modes of explaining the occurrence of these are given—first, that they are the ultimate results of the formation of crescent-shaped sand-hills, the cusps of which, travelling faster than the rest, united and became prolonged into a ridge; second, that the sand is carried along in lines by the wind; and third, that these coincident ridges have been left by winds having swept out parallel valleys through a mass of sand-hills formerly arranged normally at right-angles to its direction.

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[1] vol. ii. p. 365.

To sum up, the author concludes, first, that in recent geological times the Runn of Kutch was part of a sea inlet extending up the Indus valley and Lúní river-basin; second, the central portion of the Indian Desert about Jaysalmír and Balmír was not covered by the sea, but formed either an island or a promontory; and third, that the sand of the Desert is mainly derived from an old sea-coast, and its transport into the interior is due to the south-west wind.

The author writes of course from personal observation, and the paper displays, as might have been expected, an intimate acquaintance with both the zoological and geological circumstances of the region. W.

III.—THE YORKSHIRE LIAS. By RALPH TATE, A.L.S., F.G.S., and J. F. BLAKE, M.A., F.G.S. Illustrated by 19 Plates of Fossils, a Geologically Coloured Map, Sections, and Woodcuts. 8vo. (London, 1876: John van Voorst.)

THE volume now before us is devoted to an account of the Stratigraphical details and Palæontology of the Liassic Formation of Yorkshire. Upon taking a general glance through it, we feel inclined to think that if the Geology of every portion of the British Islands were described and illustrated in similar detail, there would be but little work left for the geologist of the future; and the number of volumes too would somewhat have overcrowded the book-room of most of us. Nevertheless, we are well pleased with the appearance of this work—its type, arrangement, and illustrations are good; and if it had only been blessed with an Index, we could have found no outward and visible fault with it. This omission in a work embracing so much detail, and whose value must largely depend upon its facility for reference, is indeed grievous, and we cannot help remarking upon it at once.

Hitherto British geology has been chiefly illustrated in two ways, firstly, by detailed descriptions of certain geographical areas, as in the Memoirs of the Geological Survey, and secondly, by detailed descriptions of certain classes of organic remains, as in the Monographs of the Palæontographical Society. The tracing out of the stratigraphical phenomena and the illustration of the life history of the rocks, when combined, form certainly the natural method of recording the geological history of our country. We could have wished that the entire development of the Lias had been described in the volume; but this, while it would certainly have detracted from the original character of the work, would probably have placed even greater difficulties than the authors have experienced, in the way of publishing a volume which necessarily appeals to a somewhat limited number of readers.

The Lias as exposed in Yorkshire forms a persistent band from

Redcar to the shores of the Humber with several inlying tracts, but apparently no outliers. The authors have carefully traced out the boundaries of its three divisions, Upper, Middle, and Lower Lias; and these are coloured on a map drawn to the scale of half-an-inch to a mile, which accompanies their volume. The Rhætic beds are so feebly developed that they have not been able to separate them from the Lower Lias on the map.

The first part of the work commences with a general account of the range of the Liassic strata on the Continent and British Isles. Notices of the literature of the Yorkshire Lias are given, and its range, extent, and general characters are then pointed out. The relations with the Inferior Oolite are also discussed.

One chapter is devoted to an Historical Sketch of the Discovery and Industrial Applications of the Cleveland Main Seam; the beds of Jet and Jet-working receive due attention, as likewise do the faults and the basaltic dyke. The bulk of Part I. is, however, taken up with the minute account of the strata and their fossils, of which latter a synoptical table is given.

The zones described in the Lower Lias are those of *Ammonites planorbis*, *A. angulatus*, *A. Bucklandi*, and *A. oxynotus*.

Oppel's zone of *A. Turneri* is included in that of *A. Bucklandi*, because the species associated with it are common forms in the latter zone. Nor do the authors find sufficient palæontological reasons for adopting the zones of *A. obtusus* and *A. raricostatus*, the latter including part at least of what they call the region of *A. armatus*, and include in the Middle Lias.

In the Middle Lias they recognize the zones of *A. Jamesoni*, *A. capricornus*, *A. magaritatus*, and *A. spinatus*, but include Oppel's zone of *A. Ibex* with that of *A. Jamesoni.* The Upper Lias is described under the zones of *A. annulatus*, *A. serpentinus*, and *A. communis*. The junction-beds with the Inferior Oolite are described as the zone of *A. Jurensis*, and from these they exclude the Blea-Wyke (sometimes called Blue Wick) beds.

In their concluding chapter the authors draw attention to the nature and origin of the Yorkshire Lias. No portion of the beds was in their opinion deposited in very deep water, but they find two distinct areas possessing distinct features, and which separation, begun in early Liassic times, appears to have continued throughout the Jurassic epoch, being exemplified by the characters of the Lower Oolites, and the development of Corallian and Portlandian strata.

In lithological characters the Lias is very variable, and yet its great thickness, and complete representation of every portion in one form or another, make the Yorkshire series a better exemplification of the whole deposits of the period than can be found in any other locality. The great feature, as they remark, is the palæontology, and the determination of those zones of life which puzzle the naturalist and sometimes raise the scepticism of the field-geologist. The cause of these life-zones they cannot explain. The change of Ammonite-forms is not due to the surrounding physical agencies that are observable, but to some others which have left no indication of their action. It is true, as they observe, that we have no proof that the animals of a zone in one locality were coeval with those of the same zone in another, though the succession may be the same. Nevertheless, whatever interpretation we put upon the facts, they remain of great interest. Their determination requires long and patient research, and has an important bearing upon the development of life; but we cannot help remarking upon the fact that the zones adopted by Messrs. Tate and Blake differ considerably from those determined by Dr. Wright in the south-west of England, while the palæontological line between the Lower and Middle Lias, always the most unsatisfactory of geological divisions, differs considerably from that taken by Mr. Judd in the Midland district.

Part II. is devoted to Palæontology proper, or the description of the Liassic fossils of Yorkshire. Each author has here devoted himself to particular portions of the work. Mr. Blake describes the Reptiles, Fishes, Cephalopods, Insects, Crustacea, Echinoderms, Actinozoa, Porifera, and Foraminifera; while Mr. Tate has given his attention to the other Mollusca, the Annelides, and the Plants. The new species and some others are figured in the nineteen plates of fossils which accompany this volume. Mr. Blake has treated the Ammonites as a family, and adopted the German method of splitting up the series into genera under distinct names, a plan which certainly does not seem to us to confer a benefit upon the student, who would gladly have less names to remember by the amalgamation of species and genera.

The volume is a valuable contribution to geological literature, and reflects every credit upon its painstaking authors.

IV.—Recherches sur le Terrain Crétacé Superieur de l'Angleterre et de l'Irlande. Par Charles Barrois, D.Sc. (Lille, 1876.)

In a Memoir of more than 200 pages, accompanied by a coloured map and sections, Dr. Barrois has given us the result of his researches on the Upper Cretaceous series of England and Ireland. Many valuable papers on the White Chalk have appeared by Mantell, Phillips. Woodward, Godwin-Austen, Meyer, C. Evans, Whitaker, and others in England; Hébert, Mercey, De Lapparent, Potier and D'Archiac in France; but no general and elaborate *résumé* has, we believe, appeared on the subject. Prof. Hébert has, however, given his views of the classification of the Upper Chalk in a paper read before the French Geological Society;[1] and has also compared the Palæontological Zones of the Dover Chalk with the divisions of the Chalk in the Paris basin. The object of the work by Dr. Barrois is to trace from an examination of the coast, as well as inland sections, both the Lithological and Stratigraphical as also the Palæontological characters of the Upper Chalk (Cénomanien, Turonien, and Sénonien) of England and Ireland; from which it appears that the English Chalk presents a succession of different faunas or distinct Palæontological Zones, entirely comparable to those recognized by M. Hébert in the basin of Paris and to those of the north-west of Germany.

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[1] Bull. Soc. Géol. France, 3 sér. t. iii. p. 595; t. ii. p. 416; *ibid* 2 sér. t. xx. p. 605; t. xvi. p. 149; t. xxix. p. 453.

The work is divided into five chapters, which treat successively of the basin of Hampshire, the basin of London, the Chalk of the North of England, and the Chalk of Ireland. The subjects are again further divided into a geological description of the strata according to their distribution in the different districts. Thus, the Hampshire basin is described under its northern, southern, eastern and western regions. This is followed in the second part by the various movements to which the surface has been subjected, such as the oscillations contemporaneous with the Cretaceous deposits, and those posterior to them, the relations of the anticlinal lines with former dislocations, and the comparison of the anticlinal lines of the basin of Hampshire with those of the basin of Paris; from which it appears that there are three principal anticlinals in Hampshire, which are parallel to each other, the axis of Kingsclere, that of Winchester, and that of the Isle of Wight and Purbeck. In comparing these with the undulations of the Chalk in the basin of Paris, described by M. Hébert and others, M. Barrois considers that the first is coincident with or a prolongation of the axis of Artois, the second with that of the valley of the Brésle, and the third with that of Bray.

A similar treatment is adopted in the chapter on the basin of London, the second part describing the causes which have brought about the variations of the Chalk of that region, either anterior to, or contemporaneous with, or posterior to, its deposition; followed by a description of the denudation and the effects which have, with the previous oscillations of the surface, produced the general physical features, and the formation of basins and valleys. The Chalk of the North of England and that of Ireland forms the subject of the next two chapters; the former describing the Chalk of Lincolnshire and Yorkshire, and its comparison with that of Norfolk. This northern division is also considered comparable with the Cretaceous strata of North-west Germany, and therefore somewhat analogous in this respect with the Lower Cretaceous strata (Speeton beds) of Yorkshire, as shown by Mr. Judd.

The Chalk of Ireland is fully described, both as regards its different lithological character and according to its different zones and contained fossils, of which the following table is a *résumé*, showing their comparisons with that of England, from which it appears that in Ireland there are no Cretaceous beds older than the zone of *Pecten asper*.

IRELAND.		
A. White Chalk with flints	Zone of *Bel. mucronata*	Sénonien
B. Ditto	,, *Marsupites*	
C. Chloritic Chalk	,, *Micraster cor-anguinum*	
	,, *Mic. cor-testudinarium*	
D. Chloritic Sand and Sandstones ...	,, *Holaster planus*	Turonien
	,, *Terebratulina gracilis*	
E. Grey Marls and yellow Sandstones	,, *Holaster subglobosus*	Céno-manien
F. Glauconitic Sands	,, Pecten *asper*	

From the facts described in the preceding chapters of the work, Dr. Barrois concludes that the English Chalk is composed of a certain number of zones, equally characterized both stratigraphically and palæontologically, as shown in the table given at pp. 222–23, and here reproduced (see TABLE, pp. 516–517), and that these subdivisions can be compared with those established for the Chalk of the basin of Paris and the North-west of Germany. All this region formed one climatic zone, and has been subjected to the same general movements of the surface, both before, during, and after the Cretaceous epoch. The movements anterior to this epoch have bearings with the formation of the Cretaceous basins, the posterior movements have determined the foldings of the strata; and that these foldings, both in England and on the Continent, have a relation in direction to much earlier dislocations, showing that the same movements of the surface have been repeated at long intervals.[1] Further, these foldings have considerably influenced the effects of posterior denudation; the rivers of the north of the basin of Paris flow in the great Cretaceous undulations, as those in the basin of Hampshire at the Quaternary epoch; the rivers in the South of England flow in the transverse dislocations.

Although some of the conclusions of Dr. Barrois on the correlations of certain divisions of the Cretaceous rocks may not be entirely accepted by his brother geologists in England, yet they must admire the industry of the young French geologist, necessary for the production of this memoir, and the careful and philosophic spirit with which the subject is treated, the result not only of his own researches, but from a full acquaintance with the literature of the subject, to which he constantly refers and quotes from throughout his paper, and in which some of his previous opinions are modified; for this, although the most extensive, is not his first notice of the Chalk of England.[2]

We have had personal opportunities of seeing the careful and systematic manner with which Dr. Barrois observes and collects in the field, the result not only of a thorough interest in his work, but possibly also of a previous good training, and in this respect he is a worthy pupil of an equally worthy and energetic teacher,—Prof. J. Gosselet, to whom this memoir is dedicated, and which must form a necessary addition to the library of every student of Cretaceous Geology.

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[1] Page 118. "Ondulations de la Craie dans le sud d'Angleterre," Ann. Soc. Géol. du Nord, t. ii. p. 85. Dr. Barrois has explained the bearings of these undulations of the Chalk on the proposed Channel Tunnel in two letters, published in the Révue Scientifique, April, May, 1875. See also M. Hébert, Bull. Soc. Géol. France, 2 sér. t. xxix. p. 583; ibid. 3 sér. t. iii. p. 512.

[2] Description géologique de la Craie de l'Ile de Wight, Paris, 1875. See also Ann. de la Soc. Géologique du Nord, Lille, 1874, 1875.

General Classification.		Sussex.	Hampshire.	Wiltshire, Dorsetshire, Devonshire.	Isle of Purbeck, Dorsetshire.	I
CENOMANIEN.	Zone with *Am. inflatus*		Grey Grit Langrish	*Gaize* of Devizes Blackdown beds	Argillaceous Sands, Lulworth Cove	Fo
	Zone with *Pecten asper*		Greensand of Barrow Hill	Chalk with quartz grains Lyme Regis, Greensand, Warminster	Grit Durdle Cove	Gl Fo
	Chloritic Marl	Glauconitic Marl of Eastbourne		Chalk with quartz grains White Cliff Glauconitic Marl Wichfont.	Glauconitic Marl Man-of-War Cove	Gl Fo
	Zone with *Holaster subglobosus*	Marl of Eastbourne	Marl of Alton	Marl Maiden Newton	Chalk with Flint Worbarrow	Gr (7)
	Zone with *Bel. plenus*	Marl of Holywell	Marl of Wilsham	Chalk ?	Marl Lulworth Cove	Ch (6)
TURONIEN.	Zone with *Inoceramus labiatus*	Marl of Houghton	Marl of Charlton	Sandy Limestone of Beer quarries	Nodular Chalk Sandy Hill	Con Sh
	Zone with *Terebratulina gracilis*	Marl of Ramscombe	Marl of Winchester	Chalk with Flint, Coast of Beer	Chalk White Nore	Cha Fli
	Zone with *Holaster planus*	Chalk-rock of Beachy-Head	Chalk-rock of Stapleford	Chalk Rock, White-Sheet Hill	Chalk Rock Mewps Bay	Nod
SENONIEN.	Zone with *Micraster cor-testudinarium*	Chalk of Cuckmere Haven	Chalk of Stockbridge	Chalk Broadchalk	Chalk Steepleton	Ch Fli
	Zone *M. cor-anguinum*	Chalk of Berling-Gap	Chalk of Leckford	Chalk Signal of Beer	Chalk Ballard Hole	Br
	Zone with *Marsupites*	Chalk of Brighton	Chalk of Salisbury	Chalk Dorchester	Chalk Pinnacles	M
	Zone with *Belemnitella*		Chalk of Portsdown	Chalk Riddletown	Chalk Studland Bay	

RREY.	BERKSHIRE	BUCKINGHAMSHIRE.	CAMBRIDGESHIRE.	NORFOLK.	YORKSHIRE.	IRELAND.
r Stone tham	Grit Woolstone	Marl Puttenham	Cambridge	Red Chalk Hunstanton	Red Chalk Speeton	
stone stham	Sand Wallingford	Sand Buckland	absent	absent	absent	F. Glauconitic Sands
oritic Marl	Chloritic Marl ?	Grey Marl	Marl Cambridge	Band with Sponges	Band with Sponges (Lincolnshire)	E. Grey Marls and
Chalk arden	Chalk Compton-Beauchamp	Marl West End Totternhoe stone	Grey Marl Cherry Hinton	Banded Chalk Hunstanton	Chalk with Red bands Speeton	Yellow Sandstones
w Chalk rden	Chalk	Chalk	YellowMarl Cherry Hinton	Grey Marl Hunstanton	Chalk	
r Marden rk beds	Chalk Uffington-Castle		Chalk conglomerate Cherry Hinton	Chalk Shernborne	Hard Chalk with Red bands Speeton	
iteleaf beds.	Chalk Streatley	Chalk	Chalk Fulbourn Lodge	Chalk Sedgeford	Chalk Hessle	D. Chloritic Sands
r Kenley (in part)	Chalk Bassildon	Chalk Rock	Chalk	Chalk Bircham-Newton	Chalk and Grey Flint North Sea	and Sandstones
r Kenley (in part)	Chalk Pangbourn	Chalk	Chalk	Chalk Stanhoe	Chalk Breil point	C. Chloritic Chalk
r Kenley beds	Chalk Chase Farm			Chalk Burnham-Overy.	Chalk Flamborough Head	
ley beds	Chalk Reading			Chalk Wells	Chalk Bridlington	B. White Chalk with Flint
				Chalk Norwich		A. White Chalk with Flint

V.—Revue de Géologie pour les Années 1873 et 1874. Par MM. Delesse et De Lapparent. (Paris, 1876.)

THE French Geological Record has now reached the twelfth volume, which is carefully edited, and as full of interesting notices as the publications of previous years. Mainly intended for French geologists, the references and abstracts of papers bearing on the geology of France are more restricted than those of other countries. The matter, which includes notices of the more important papers published during the years 1873–4, is arranged under lithological, historical, geographical, and dynamical geology; special attention having been paid to the works on the metamorphism and modification of rocks. Besides a *résumé* of the chief geological memoirs, the review contains numerous unpublished analyses of rocks, either made in private, or in the public laboratories, and also special communications of interest from different authors. These give additional value to the volume, and render it not only useful to France, but a necessary work of reference for both English and American geologists.

VI.—Proceedings of the Bristol Naturalists' Society. New Series, Vol. I. Part III. 1876.

THIS third part of the New Series of Proceedings completes the volume, which in size and subject-matter will bear very favourable comparison with the Proceedings of other local Natural History Societies. It numbers in all 506 pages, and is well illustrated with plates and woodcuts. The improvement over the old series is, we believe, largely due to the energy of Mr. E. B. Tawney, F.G.S.

In this part, Mr. Stoddart continues his account of the geology of the Bristol Coal-field, treating of the Carboniferous Rocks—the Carboniferous Shales, the Mountain Limestone, Millstone Grit, and Coal Measures. Although so much has been written upon the physical structure of this district, the palæontology has hitherto by no means received adequate attention, so that the lists of fossils furnished by Mr. Stoddart form a most valuable addition to our knowledge.

Mr. Tawney contributes some useful and suggestive notes on Prof. Renevier's Geological Nomenclature and Table of Sedimentary Rocks; he has also taken up the vexed question of the age of the Cannington Park Limestone, and both his personal observations on the rock and the fossils he has obtained lead him to advocate its Carboniferous age.

Mr. J. G. Grenfell describes and illustrates in two well-executed plates some Carboniferous Encrinites from Clifton and Lancashire.

Accounts are recorded of excursions to Wells and Glastonbury, to Ilminster, and to the Yate Rocks; and the volume concludes with an obituary notice of William Sanders, whose loss to local students of science is particularly felt.

CORRESPONDENCE.

FOSSIL PALÆOZOIC INSECTS.[1]

SIR,—In Mr. Henry Woodward's recent paper on a new and remarkable Orthopterous Insect (*Lithomantis carbonarius*) from the Coal-Measures of Scotland (Quart. Journ. Geol. Soc. Lond., 1876, vol. xxxii. p. 60, pl. ix.), is given a list of known Palæozoic fossil forms, to which I would venture to make some slight additions. Most remarkable to my mind is the constant discovery of close relationship between the ancient forms of Insect-life in Europe and America, which Mr. Woodward has been one of the most conspicuous in pointing out. I shall add as another fact tending in the same direction that my *Megathentomum* and Goldenberg's *Acridites* are but two closely allied species of one genus.

Allow me to observe that *Archimylacris* is a Carboniferous, not a Devonian type (see my paper, GEOL. MAG. 1868, Vol. V. p. 177), and that my *Mylacris* is not a Neuropterous, but an Orthopterous type. Mr. Woodward cannot have seen Goldenberg's Fauna, *Saræpontana fossilis* (1873), or its predecessor the Jahresbericht Gymn. zu Saarbrücken (1867), in which a *Blattina Tischbeinii* is described.

I venture to send what I believe to be a complete list of the Carboniferous Insects of America arranged by families.

LIST OF DESCRIBED AMERICAN INSECTS FROM THE CARBONIFEROUS FORMATION.

ORTHOPTERA.

1. *Blattina venusta*, Lesq., 2nd Rep. Geol. Ark., p. 314.
2. „ *Heeri*, Scudd., Can. Nat. (N.S.), vol. vii., p. 272.
3. „ *bretonensis*, Scudd., Can. Nat. (N.S.), vol. vii., p. 271.
4. „ *sepulta*, Scudd., Proc. Am. Asso. Adv. Sc., vol. xxiv., p. 111.
5. *Mylacris anthracophilum*, Scudd., Geol. Ill., vol. iii., p. 568.
6. *Archimylacris acadicum*, Scudd., Daws. Acad. Geol., p. 388.
7. ? *Mantis sp.* Scudd., Geol. Ill., vol. iii., p. 567.
8. *Archegogryllus priscus*, Scudd., Proc. Bost. Soc. Nat. Hist., vol. xi., p. 402.

NEUROPTERA.

9. *Miamia Bronsoni*, Dana, Sill. Journ. (2), vol. xxxvii., p. 34.
10. „ *Danæ*, Scudd., Geol. Ill., vol. iii., p. 566.
11. *Hemeristia occidentalis*, Dana, Sill. Journ. (2), vol. xxxvii., p. 34.
12. *Crestotes lapidea*, Scudd., Geol. Ill., vol. iii., p. 567.
13. *Megathentomum pustulatum*, Scudd., Geol. Ill., vol. iii., p. 570.
14. *Ephemerites simplex*, Scudd., Geol. Ill., vol. iii., p. 571.
15. „ *gigas*, Ib. p. 571.
16. „ *affinis*, Ib. p. 472.
17. *Libellula carbonaria*, Scudd., Proc. Am. Asso. Adv. Soc., vol. xxiv., p. 110.
18. *Haplophlebium Barnesii*, Scudd., Daws. Acad. Geol., p. 387.
19. *Paolia vetusta*, Smith, Sill. Journ. (3).

ARACHNIDA.

20. *Arthrolycosa antiqua*, Harg., Sill. Journ. (3), vol. vii., p. 219.
21. *Architarbus rotundatus*, Scudd., Geol. Ill., vol. iii., p. 568.
22. *Eoscorpius carbonarius*, Meek-Worth., Sill. Journ. (2), vol. xlv., p. 25.
23. *Mazonia Woodiana*, Meek-Worth., Geol. Ill., vol. iii., p. 563.

MYRIAPODA.

24. *Xylobius sigillariæ*, Daws., Quart. Journ. Geol. Soc. Lond., vol. xvi., p. 268.
25. „ *similis*, Scudd., Mem. Bost. Soc. Nat. Hist., vol. ii., p. 233.
26. „ *fractus* „ Ib. p. 234.
27. „ *Dawsoni*, „ Ib. p. 235.

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[1] The publication of this letter has by accident been delayed, owing to the temporary loss of the original.—EDIT. GEOL. MAG.

28. *Archiulus xylobioides*, Scudd., Ib. p. 236.
29. *Euphoberia armigera*, Meek-Worth., Sill. Journ. (2), vol. xlv., p. 26.
30. ? „ *major*, Meek-Worth., Ib. p. 26.

Of these, No. 8 is the only one which has not yet been figured. f No. 19 I cannot now lay my hand on the paper containing the escription. It appeared about seven or eight years ago.

Nos. 5, 7, 9, 10, 11, 12, 13, 19, 20, 21, 22, 23, 29, and 30 come rom the Ironstone nodules of Mazon Creek, near Morris, Illinois.

Nos. 14, 15, 16, come from shale, near Morris, Ill.

No. 1 comes from Frog Bayou, Arkansas.

Nos. 2, 3, 4, 6, 17, and 18, come from Cape Breton.

Nos. 24 to 28 come from Sigillarian stumps at the Joggins, Nova cotia. No. 8 comes from Tallmadge, Ohio.

Boston, U.S.A. Sam. H. Scudder.

NEW ORTHOPTEROUS INSECT IN THE COAL-MEASURES OF SCOTLAND.[1]

Sir,—I read with interest Mr. Woodward's paper on an Orthop-erous Insect from the Coal (see Quart. Journ. Geol. Soc. Lond., 1876, ol. xxxii. p. 60, pl. ix.), and I take the liberty to direct attention to ny paper on *Fossil Blattidæ* (in der Vierteljahrzchrift der tübner aturfourch., Gesellschaft, vol. ix. 1864, p. 273). In it are several pecies omitted from Mr. Woodward's list, viz.:

Blattina helvetica, Heer, from Erbignon, Valais.
——— *Fritschii*, Heer, „ Mannebach, Thuringia.
——— *clathrata*, Heer, „ „ „
——— *latinervis*, Heer, „ „ „

all from the Carboniferous period. *Blattina helvetica* is also figured in my "*Primæval World*," p. 20 (English Edition, just published, London, Longmans). Dr. Oswald Heer, Prof.

Zurich.

FURTHER DISCOVERIES OF OSSIFEROUS CAVERNS IN NEW SOUTH WALES.

Sir,—I inclose letter from the Editor of the "Bathurst Free Press," and part of a newspaper, relative to the discovery of some caves similar to those of Wellington, N.S.W., which I examined in company with the late Prof. A. M. Thomson with such happy results. I have seen some bones and teeth said to have been found there, and these are all referable to the extinct fauna of the Wellington Valley. I would have gone up; but since the discovery became known, all our *scientific ignoti* are interfering, and have requested the Trustees of the Australian Museum to take the matter in hand! Perhaps I shall have an opportunity to examine more specimens soon, and will let you know the result.

Australian Museum,
Curator's Office, Sydney,
August 5th, 1876.

Gerard Krefft,
Curator Australian Museum.

From the inclosures in Mr. Krefft's letter, we learn that *several*

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[1] This note (together with Prof. Scudder's communication) has been unintentionally omitted, the original having been accidentally lost, and only now recovered. Edit. Geol. Mag.

large CAVES containing fossil remains have been discovered in the limestone country between Cowra and Canowindra, on the road between these two places, and between 70 and 80 miles from Bathurst. The description of the caverns differs in no wise from those of other limestone districts where streams have dissolved more or less extensive chambers in the softer limestone, these chambers being connected by narrow passages, and lying at different elevations with regard to each other. The caverns are large, and decorated with stalactites. The roof of one chamber in the principal cave is said to be from 80 to 90 feet high, with some 12 or 14 openings leading into other cavities. They are stated to descend from 300 to 400 feet beneath the surface. Nearly all the caves and chambers have their floors composed of a thick layer of *ossiferous breccia* apparently quite undisturbed. Only one cave seems to have been dangerous from "*choke-damp.*" The writers are very enthusiastic as to their discoveries, and propose to explore another cave reached by a shaft 100 ft. perpendicular. We trust that no lives will be lost in this somewhat Quixotic fit of cave-hunting, and shall look forward with interest to Mr. Gerard Krefft's report on the bones from this extensive series of caves and fissures in New South Wales. —EDIT. GEOL. MAG.

GLACIAL ORIGIN OF LAKE-BASINS.

SIR,—I fear the points of difference between Mr. Hugh Miller and myself are hardly such as can be cleared up in the compass of a letter, but yet I should like to make one or two remarks on his paper, because I still think we are to some extent misunderstanding one another. My letter (p. 376) was chiefly devoted to the reasoning in Mr. Fisher's paper (p. 253); the paragraph alluding to Mr. Miller's letter (p. 287) was simply intended to call attention to a defect in his reasoning (where he now admits that he did himself injustice) and to guard against what seemed to me a misconception of my argument. An unfortunate printer's error, or slip in writing in my manuscript (it was not possible for me to revise a proof), made my meaning less clear than it should have been. Expanded, this is what I intended to imply—"Suppose you prove that a certain number of small-sized sheets of water (to avoid ambiguity we will say such as Grasmere, or less) are most easily explained by the hypothesis of glacial erosion, it does not follow that very large and deep sheets of water (such as Como) are most easily explained by the same hypothesis." The first paragraph of Mr. Miller's letter, and parts of the second and third on page 287, appeared to mean that he claimed to reason from the examples which he quoted to those cases which I have always disputed; and in his paper (p. 453) he seems to still maintain this: "It appears to me that no halting-place can logically be found by those who, with Sir Charles Lyell, allow only some mountain tarns to Prof. Ramsay's demand for lakes." It is this which I dispute. Perhaps the halting-place may not be impregnable to an attack on the destructive 'Sorites' method; but in science and in every-day life, we are constantly obliged to take our stand on similar halting-places. Thus, because blown sand erodes, am I to apply this agent in all cases where there is nothing in the nature of the cases directly to contradict me; or because a pebble on a sheet of rock may most probably have been thrown there by a lad, am I to attribute a big boulder on the same to the games of heroic youths in pre-Homeric ages? I may know that the Aletsch Glacier maintains the Märjelen See, and yet doubt the existence of a vast ice-barred lake in Northern Europe. Each case, as it seems to me, must be separately judged, having regard to all the surrounding circumstances. From this position I have never consciously receded. I admit some tarns, I admit, though with greater hesitation (for reasons which I have stated), some 'lakelets,' to be the work, wholly or in great part, of ice. I cannot believe that ice has been more than a very secondary agent in forming the great Alpine lakes.

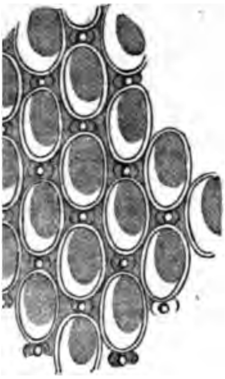
I still venture to think that Mr. Miller's reasoning (p. 453) does not remove the difficulty which I have brought forward as to the forms of the Alpine valleys above the great lakes. I have tried to show that there the glacier is as *nearly as possible powerless* as an erosive agent, or at any rate that it has only superficially modified forms, which we agree in associating with the action of running water. The glacier has all along been "indentured" in a groove, but it has been a thoroughly idle apprentice, till some cause, no more permanent than the master's stick, has quickened it into intense but brief energy. Como, Lugano, Brienz, the König See, and many others, are vale-confined glaciers: so are the greater parts of many other lakes. But with regard to these difficulties, I must content myself by referring to what I have already written.

One more point; for I do not attempt to criticize Mr. Miller's special Scotch case, as I have not examined the district. The Alps cannot be expected to give much indication of the evidence of profile which Mr. Miller demands. Plains of marine denudation cannot, so far as I know, be recognized there. I am not aware that the sea has flowed among their summits since a period prior at least to the last great movement. Mountain contours, in the regions of most lakes that I have mentioned, are so irregular that we cannot hope to recognize clearly these curvatures in them, any more than in their disturbed strata. It is a point, however, which I have not overlooked in my investigations, and may say that, while I have found nothing in this respect opposed to my theory, I have observed a few things making for it slightly, but so slightly that I preferred not to bring them forward. T. G. Bonney.

CARBONIFEROUS AND POST-TERTIARY POLYZOA.

Sir,—In the Geological Magazine for October, 1873 (Vol. X. p. 433), I proposed the name *Carinella* for a new genus of Carboniferous Polyzoa. I find that this term was pre-occupied, having been used by the late Dr. Johnston for a genus of recent Nemertidian Annelids (see McIntosh, Annals Nat. Hist. 1874, vol. xiv. p. 154), and I am therefore desirous of proposing in its place that of *Goniocladia*. I described one species (G. cellulifera), the only one at present known.

Macconochie obtained, some short time since, numerous speci- f a *Membranipora* from the Post-Tertiary beds (Carse Series) River Forth above Stirling. An examination showed that closely related to *M. Lacroixii*, but not quite identical. Ex- were forwarded to Prof. Busk, F.R.S., who considers it a new , and has done me the honour to name it after me. The ng is his description:—*Membranipora Etheridgii*, n. sp.—



"Zoæcia disposed in regular quincuncial order. Apertures entire, oval or oblong. Border thin, finely granular, unarmed. Each aperture surmounted by a blunt tubercle. At first sight resembles *M. Lacroixii*, but differs in the perfectly regular disposition of the zoæcia and the presence of the single tubercle above each aperture. This tubercle does not appear ever to present the appearance of an opening. The growth forms lace-like expansions on the surface of shells." *Loc. and Horizon*, Goodie Water, near its junction with the etc.; River Forth near Mid Frew, and other localities in the ɔurhood of Kippen, Perthshire, in Carse shelly clays of the Beach series. R. Etheridge, Jun.

nburgh, *Oct.* 11, 1876.

THE "SARSEN STONES."

—With reference to the fact of the Sarsden or Sarsen Stones of ire being perforated here and there with numerous vertical ırks, as mentioned in No. 138 of Geol. Mag., December, 1875, permit me to add that I have seen other such specimens since te, and especially near Marlborough, and at Avebury in Wilt- Among the "Grey Wethers" on the Chalk Down, near the place, I lately saw some good examples; and on a visit to y, I particularly noticed that one of the enormous upright ı, standing among the ricks of the farms, abounds with these rpendicular rootlet-holes, together with numerous horizontal stems and other plants-remains. T. Rupert Jones.

own, *Sept.* 20, 1876.

FORMATION OF ROCK-BASINS.

—In respect to the challenge thrown down to me in your last r by my friend Mr. Hugh Miller, I should have been very ntented to have left my defence in the hands of so able a on as Mr. Bonney. But lest my silence should be interpreted ating a lack of courtesy as well as of courage, I respond to sonal appeal which is now made to me.

r. Miller's article is rightly understood by me, I gather, that ɔrepared to admit the overwhelming probabilities in favour of w that the formation of the great Alpine lakes is due to the combined action of subaerial erosion and subterranean movement, he finds two obstacles to his acceptance of the same explanation in the case of certain smaller lakes. Most happy should I be if any remarks of mine sufficed to meet the difficulties expressed by so candid a reasoner as Mr. Miller.

His first argument is propounded by Mr. Miller in the following terms: "It appears to me that no halting-place can logically be found by those who, with Sir Charles Lyell, allow only 'some mountain tarns' to Prof. Ramsay's demand for lakes; that either a glacier is inadequate to hollow even a tarn, or that it can enlarge it to any reasonable proportions." Need I point out to my friend that everything in this controversy depends on the sense that we are to attach to this highly elastic phrase "reasonable proportions." If any one, for example, were found bold enough to suggest that the rock-basins of the Black Sea, or the two occupied by the Mediterranean, or the larger ones which hold the Atlantic, Pacific and Indian Oceans respectively, were scooped out by glaciers (and really one would not be surprised at anything being claimed for ice-action at the present day), of course Mr. Miller would admit that these were *beyond* "reasonable proportions," to be produced by such a cause. Yet it would certainly be as easy to adduce a series of rock-basins, constituting an insensible gradation from a Scotch loch up to even the largest examples which I have cited, as it would be to construct a similar series downwards into the tiniest tarn. There is surely no more want of logic in stopping at one point rather than at another in this perfectly graduated series. My own faith in the powers of glacier erosion stops short of anything that, without flattery, could be called "a lake" at all; some are gifted with powers of belief that will embrace Cumberland meres and Highland lochs; more strongly constituted minds do not pause before an Alpine lake; and a few (but these must be inspired with "faith that could remove mountains") have claimed that Lake Superior itself may be "glacier-formed." I cannot help thinking that Mr. Miller will, on reflection, perceive the fallacy embodied in the oft-repeated assertion that, granting irregularities of surface may be produced under a glacier, all that is required for the production of the vastest lakes is a sufficient volume of moving ice. Does not a Highland burn wash out many a tiny basin under its waterfalls, and at other points in its course? Yet who would venture to assert that, because the Mississippi has many thousand times the volume of the Highland burn, it could make basins many thousand times as big?

In the second argument raised by Mr. Miller, great stress is laid upon the undisturbed condition of the so-called Cambrian beds of Sutherland. But while, as compared with neighbouring rocks, these appear "nearly horizontal," I have not the smallest doubt that when they come to be carefully studied in detail, their wonderful parallelism and regularity will be found—as in the case of the Alpine dolomites, which present quite as regular an appearance when seen from a distance—to be a mere optical delusion; and that these ancient masses have been subjected to flexures and fractures not a few, each of which was more than sufficient to dam up the drainage in a Highland glen.

Mr. Miller suggests that "when the mechanics of glaciers is better known," it will appear that the appetite of glaciers for digging will grow with what it feeds on. Possibly this may be so; but, as the present state of our information on the subject leads us to infer that the laws governing the movement of rivers of ice are similar to those which determine the flow of streams of water, it seems to me that our knowledge will have to be very much bettered indeed, before such a proposition stands the smallest chance of general acceptance.

JOHN W. JUDD.

ON THE SILURIAN ROCKS OF SWEDEN.

SIR,—In the August Number of your MAGAZINE there is a letter from Mr. Hicks directed against me, and though it is of little use to discuss with Mr. Hicks, who, instead of arguments, usually sets forth only assertions, I shall say a few words, in order to point out some mistakes and mis-statements in that letter.

When Mr. Hicks in the beginning of his letter says, "that Dr. Linnarsson is unable to put forward stronger evidence in opposition to these [Mr. Hicks'] views is clearly a powerful argument in my favour," I must remark that my letter in the June Number (of which here is the question) was not intended to be a critique of Mr. Hicks' views in general, but only to refute his reasonings in the letter inserted in the May Number. I think that every attentive reader will find that I have sufficiently shown their weakness, and then nothing more can be required.

Mr. Hicks now seems to hold it at least possible that the Paradoxides beds of Sweden represent also the lower parts of the Menevian beds, but then he adds, to my astonishment, that "there is no evidence of a previous fauna." One might have thought that Mr. Hicks, from what I have written in the April Number of the GEOLOGICAL MAGAZINE, would have known that there are below the Paradoxides beds two faunas, that of the Fucoid Sandstone, and that of the Eophyton Sandstone.

I doubt whether Mr. Hicks knows much more of the stratigraphical and palæontological characters of the oldest Russian beds. He himself says, it is true, that, with regard to the Russian beds, he has "looked to the general order of the deposits, and the general character of the fauna, for a clue." But I dare say that it is my opinions of their age, and not his, that are supported by "the general order of the deposits," and that hardly any one who has the slightest acquaintance with the Swedish and Russian beds can come to such conclusions as Mr. Hicks in this matter. From the Orthoceras Limestone down to the Dictyonema Schists inclusively, there is quite the same series of beds in the Swedish and the Russian area, and therefore it cannot be denied that the Dictyonema Schists of both areas are equivalent, "if the general order of the deposits," to which Mr. Hicks has himself appealed, is to be relied upon. As to "the general character of the fauna," I (and, I think, geologists in general) should very much like to know which are the fossils of the strata underlying the Dictyonema Schists to which Mr. Hicks refers as being "Silurian in type and not Cambrian." To me the scanty knowledge of the fauna of these beds does not seem sufficient to warrant, *per se*, a conclusion as to their age. Fortunately, the sequence of the strata gives a good clue. The Dictyonema Schists of Sweden are very nearly related to the Olenus Schists, which they always immediately overlie, in some places seemingly without any sharp line of demarcation. The Olenus Schists of Sweden are exactly equivalent to the Lingula Flags of England, and therefore the rocks underlying the Russian Dictyonema Schists cannot, at least, be younger than the Lingula Flags, if we are to judge from the palæontological evidences, and from the sequence of the strata.

Mr. Hicks says that if I could only be brought to recognize his views of the gradual encroachment of the sea from a western or south-western direction over the European area, I should certainly feel none of those difficulties which now occur to my mind. It may be so, but it is my habit, in scientific investigations, first to make myself acquainted with facts, and then to proceed to generalizations. Even if Mr. Hicks may think it more proper and easy first to form theories, and then to "dispose of" the facts, so that they may not interfere with the theories, I cannot help thinking that the opposite way is the true one, and that the knowledge of facts must forego the forming of theories. As I—and probably also your readers—now begin to feel tired of the paper war with Mr. Hicks, I shall not hereafter pursue it. G. LINNARSSON.

SECTION OF BOULDER-CLAY, NORTH DOCKS, LIVERPOOL.

SIR,—As a natural consequence of the two recent letters in the GEOLOGICAL MAGAZINE, in reference to the Boulder-clay recently exposed in the new dock works to the north of Liverpool, I beg to hand you a copy of the Report I sent, as a member of the Committee, to the Rev. H. W. Crosskey, F.G.S., Secretary of the Boulder Committee of the British Association.

"Recently very extensive excavations have been made in the Boulder-clay at Bootle, a northern suburb of Liverpool. The site is intended for new docks, and extends along the River Mersey, being reclaimed from the shore within the tidal range. The following is a section of the Drift deposits that have been exposed continuously over many acres; but the thickness of each varies considerably according to position, and the Middle Sands and Gravels often thin out and leave the Upper Boulder-clay reposing on the Lower Boulder-clay.

1.	Sand and Silt of the old shore	17 feet.
2.	Upper Boulder-clay	15 „
3.	Middle Sands and Gravels	6 „
4.	Lower Boulder-clay	6 „
	(Bunter Sandstone)	

"The whole of these subdivisions repose, each in succession, on the Bunter Sandstone at that part of the section nearest the old coast-line.

"The Lower Boulder-clay contains a much greater quantity of small stones than the Upper Clay. No large boulders were observed; but as the Lower Boulder-clay is not exhibited to any considerable depth, it may possibly contain some such boulders.

"The Middle Sands and Gravels consist of sands which frequently by the great increase of rounded pebbles become gravels exactly resembling those at Preston Junction and Wigan in Lancashire, and Gresford, Corwen, and Colwyn in North Wales.

"The Upper Boulder-clay contains comparatively few small stones, but many large boulders, two or three feet in diameter. Many of these are striated, and are composed of a dark greenstone; but some are Criffel and Eskdale granite. These large boulders probably occur at an average distance of twenty yards from each other. A mass of compact gypsum about 4 ft. in diameter was also observed.

"The excavators always worked the Upper Clay with a spade, and the Lower Clay with a pick, in consequence of which the difference between the two clays could be distinguished at a considerable distance, whether the Middle Sands and Gravels were between them or not."

I may now add that for many months during the progress of the excavation the section was of the clearest possible character. Over an area of many acres, the Upper Boulder-clay had been removed, as well as the underlying Sands and Gravels, leaving the Lower Boulder-clay untouched except where it rose above the general level intended for the bottom of the Docks. In such instances it was directly covered with the Upper Boulder-clay—though the line of separation was invariably clear and distinct. The Middle Sands and Gravels varied continuously, from fine and coarse sand into gravel and pebble beds; and indicate very different conditions of deposition compared to that of the two Boulder-clays. In conclusion I need only remark that this tripartite division of Glacial deposits at Liverpool strengthens similar conclusions in North Wales and Lancashire, and proves their general application over a wide area.

122, London Road, Liverpool. George H. Morton.

THE GRAPTOLITIC MUDSTONES OF THE LAKE DISTRICT.

Sir,—Mr. C. Lapworth's argument in favour of the Graptolitic Mudstones of the Lake district being Lower Llandovery would be very strong if there was a physical break between them and the overlying formations, but this is not the case. The Mudstones graduate upwards into the pale and purple-coloured slates, which in their turn graduate upwards into the Coniston Flags, and so upwards into the Bannerdale beds. From the base of the Mudstones to the top of the Bannerdales is one conformable series. The disappearance of the Graptolites of the Mudstones is not sudden, they are found in the dark bands interstratified with the pale slates to the very top.

I do not believe there can be an enormous break indicating a long lapse of time without there being some signs of unconformity or overlap; in this case there is none, not even a sharp junction.

Kendal, 20*th Oct.*, 1876. W. Talbot Aveline.

MR. READE ON DRIFT-SEQUENCE, AND MR. MILNE ON COAST-ICE.

SIR,—In answer to Mr. Mellard Reade's letter in your last, I ought to state that my object in calling attention to the Liverpool section was mainly to show that the Brick-clay of the N.W. of England is fully entitled to the epithet *Boulder-clay;* and that it is an original Boulder-clay, is proved by the number of limestone pebbles it contains which exhibit fine *white* scratches which would have been dimmed if not effaced by a process of re-transportation. The Liverpool drift-section does not show the three-fold division clearly, but even there we find gravel-beds full of *erratic* pebbles which must have been washed out of a *pre-existing glacial clay* (of which only hummocky patches remain), and their striæ effaced during an inter-glacial period when the transportation of striated stones had ceased.

You have lately published two very important articles on sea-ice, especially the article by Mr. Milne, which I think may be regarded as settling the question relative to the *superiority of coast-ice* as a transporting agent, and (with the exception of the more typical *roches moutonnées*) as a glaciating agent. That floating coast-ice did most of the work of transportation, and (so far as stones are concerned) glaciation, may be safely inferred from the glacial phenomena of the N.W. of England and Wales, as I have endeavoured to show in many articles in this MAGAZINE, and in the Quart. Journ. Geol. Soc.

D. MACKINTOSH.

HUMAN REMAINS BENEATH BOULDER-CLAY?

SIR,—In the present Number of the GEOLOGICAL MAGAZINE, p. 476, there is an instance recorded of flint implements, mammalian bones, etc., found in Brick-earth below the Boulder-clay in East Anglia.

I thought it might interest the readers of the GEOLOGICAL MAGAZINE sufficiently, to justify me in recording the following which came under my notice the other day (16th inst.).

While some men were engaged in a brick pit by Voryd, Rhyl, they dug up, from a depth of 4 feet of slaty clay, a human skull with four teeth attached, a rib and piece of shoulder-bone; above the clay is a thickness of 3 feet of sand.

I am not competent enough to assign the right date to this clay, but believe it to be older than the Boulder-clay which is very plentiful in this district. A little inland from the above, the Boulder-clay lies in a great thickness above the slaty clay, with a band of peat and trunks of trees in some place intervening; but as we approach the sea, the Boulder-clay is wanting, and the following section is found:

Soil	1 ft.	3 in.
Shingle with shells	2	0
Sand with shells	2	0
Slaty clay	2	0
Peat	3	0
Slaty clay, depth not known.		

SAML. PARRY.

RHYL, *Oct.* 17*th*, 1876.

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ORIGINAL ARTICLES.

I.—Contributions to the Study of Volcanos.—Second Series.

By John W. Judd, F.G.S.,
Professor of Geology in the Royal School of Mines.

On the Volcanic Outbursts which accompanied and followed the Formation of the Alpine System.

OF the amount of vertical movement which took place in the great mountain axis of the Eastern continent, subsequently to the deposition of the Eocene strata, the following facts afford sufficient proof. The marine Nummulitic rocks, besides constituting very large portions of the flanks of this vast mountain axis, and of its connected chains, such as the Pyrenees, the Carpathians, and the Caucasus, form the actual summits of such grand Alpine peaks as the Diablerets, and the Dent du Midi, rising to the heights of 10,670 and 10,531 respectively above the sea-level; while in Western Thibet the same Eocene strata are seen raised to an elevation of no less than 16,500 feet above the sea.

But even these measures, vast as they are, supply us with a very inadequate conception of the amount of disturbance to which the district in question has been subjected during the post-Eocene epoch. In order fairly to realize the all-powerful action of the subterranean forces at work in the later Tertiary periods, we must examine the enormous beds of sand and pebbles constituting the Lower, Middle, and Upper Miocene of the Western Alps, and presenting an aggregate thickness in places of between 7000 and 8000 feet—telling, as they do most unmistakably, of local subsidences of not less than that amount with subsequent re-elevations to an equal extent.

It is only, however, when we come to examine the constantly highly inclined, the frequently vertical, and sometimes greatly contorted and even inverted positions of these Miocene rocks, that we are fairly impressed with the magnitude of those earth-movements, of which these districts were the scene during the second half of the Tertiary epoch. These facts, of which we find such striking evidence in Switzerland and the Western Alps, are equally patent to the geological student in Eastern Europe. In the Tsil Thal on the flanks of the Transylvanian Alps, for example, a portion of a vast deposit of Oligocene strata, consisting of clays, sandstones and coals, with a thickness of between 2000 and 3000 feet, has been bent into a sharp synclinal fold, and this fragment has alone survived the denuding action which has effected the complete removal of every trace of the strata of the same age from the whole of the country around.

But even in respect to geological times comparatively much more recent, we find abundant evidence of the occurrence of movements of considerable extent, if of less violence, in this portion of the earth's crust. On the southern side of the great mountain axis, where disturbances seem to have been prolonged to a later period than on its northern margin, there have been subsidences sufficient to permit of the accumulation of more than 3000 feet of Pliocene or Subapennine strata; and these subsidences have been followed by upheavals, which at some points, as in Sicily, have raised the marine beds to heights of more than 3000 feet above the sea-level. And here again we find the evidence in Eastern Europe quite in accord with that found in the West. For example, the Congerian and Paludina strata of Sclavonia, the equivalents of the Pliocene of Western Europe, have a thickness of more than 2000 feet; and they have been clearly subjected to very considerable local disturbances during those movements of upheaval, through the agency of which they are now exposed at the surface.

That even in post-Pliocene times movements of no insignificant amount took place, we have also abundant evidence. In our own country, marine shells at an elevation of 1400 feet in Moel Tryfaen and 1200 feet at Macclesfield tell of subsidence and re-elevation during the so-called Glacial period, of which these measures are the minimum limit. The evidence derived from these marine shells at such great elevations can only indeed be got rid of by such violent hypotheses as those of the Universal Deluge sweeping everything before it in its passage, or of Messrs. Belt and Croll's "ice-caps," which scrape up ocean-bottoms and push them on to mountain-tops. For our own part, if compelled to choose between these two hypotheses, we should decidedly confess to a preference for the older, which has also the advantage of being an orthodox one.

Nor were the movements which took place in our own country in post-Pliocene times by any means exceptional, for there are many facts which point to more extensive and violent ones having occurred during that period in the Western Alps.

The great changes which were brought about during the same period in the physical geography of Eastern Europe (though there, probably from local causes, unattended with those extreme glacial conditions which characterized Western Europe and Eastern America) bear witness to the continued activity of the subterranean forces. Nor have we any reason for doubting that these forces still retain some of their activity—difficult as it may be to demonstrate their effects by means of the monuments belonging to the insignificant periods of human history.

Now all the facts derived from a study of the positions assumed by Tertiary strata of different ages, both in Western and Eastern Europe, point to the same conclusion—namely, that within and around the great mountain axis of the Eastern continent subterranean sturbance, commencing in the Oligocene period, and thence gradu- y augmenting in violence, attained its climax towards the close of e Miocene, and then as gradually died away during the Pliocene st-Pliocene, and recent periods; the movements on the southern nks of the axis being more prolonged than on its northern side.

And it is a most interesting circumstance that a very striking rela- on can be shown to exist between these movements in the great ountain axis itself and the activity of the volcanic belt which retches on either side of it. The volcanic outbursts which, as we ve seen, commenced in the Oligocene period, acquired continually w strength and vigour, till at the close of the Miocene they had ilt up a series of volcanic cones, rivalling Etna in their proportions d forming almost continuous chains stretching on both sides of d parallel to the great mountain axis; but, from that period down the present, the volcanic activity has been in a state of continual at gradual decline, the vast cones falling into ruin, and the dying bterranean energies sufficing to produce only long lines of splutter- g "puys;" till finally geysers and mud-volcanos, hot-springs and aseous exhalations, testify to their having reached the stages of ex- austion, senility and utter decay. Yet this decline certainly took lace faster on the northern side of the axis—where not a single active ent at present remains—than on its southern side—where Etna nd Santorin, Vesuvius, Stromboli, and Volcano retain something of e fires of their youth; and where not a few outbursts during the istorical period in the same Mediterranean area have served to emind us that forces as yet unspent still have their habitation eneath it.

We have already spoken of the evidences of the gradual appear- nce and growth in energy of the volcanic forces on both sides of he Alpine system during the Oligocene period. We will now riefly sketch, so far as the materials at our disposal enable us to do o, the actual condition of the volcanic centres which surrounded he Alpine system at the period of their maximum violence, towards he close of the Miocene period.

Among the most interesting of the facts established during the oyage of the "Challenger" is that of the existence of a great sub- nerged ridge stretching from north to south through the Atlantic. The few peaks of this ridge, which rise from depths of 25,000 feet, nd now reach the sea-level, there forming groups of islands, are lmost all volcanic, though usually either extinct or exhibiting vidences of various stages of decadence. It is hardly possible to loubt that the subsidence and submergence of this vast ridge is onnected with the gradual decline of volcanic energy beneath it. The evidence obtained in Greenland, the Hebrides, Madeira, and the zores, all points to the inference that the period of maximum ctivity in this volcanic band was the Upper Miocene; and certain acts in our own islands suggest the conclusion that the commence- nent of volcanic action in it must be referred to a somewhat earlier ortion of the Tertiary period. Hence it is not difficult to picture o ourselves the existence in later Tertiary times of a great band of volcanic peaks, comparable in magnitude and parallel in position with the range which now forms the western boundary of the great American continent. Of this great volcanic chain we trace the structure of portions still unsubmerged in Franz Josef Land, Spitzbergen, Greenland, Jan Mayen Island,[1] Iceland, the Faroe Islands, the Hebrides, the North-East of Ireland, the Azores, Canaries, and Cape de Verde Islands, Fernando Neronha, Ascension, St. Helena, and Tristan d'Acunha, in some of which eruptive action is wholly extinct, while in others it still retains a considerable degree of vigour.

From this great Atlantic volcanic band there extended in Miocene times one great branch to the westwards running through the Arctic Archipelago, and two great branches stretching eastwards; one of these latter being situated on the northern side of that great zone of subterranean movement which now forms the mountain axis of the Eastern Continent, and the other lying on the southern margin of the same disturbed district.

The northern volcanic chain was constituted as follows. In what is now the Auvergne rose the vast trachytic and phonolitic cones of the Mount Dore, the Cantal and Mount Mezen, so well described by the late Mr. Poulett Scrope; each a lofty mountain comparable to Etna in its proportions. Following a line parallel to a great curve of the Alpine main axis we are conducted by the smaller outbursts of the Black Forest and Odenwald to the district of the Lower Rhine. Here the greatly denuded masses of the Siebengebirge, the Westerwald, the Habichtswald, and the Rhon-gebirge, with the less ruinous mass of the Vogels-gebirge, indicate the existence of vast volcanic cones in the Miocene period, not inferior in dimensions to the three great volcanos of the Auvergne. The series, interrupted for a short distance by the great lateral axis now forming the ranges of the Thuringer Wald, the Franken Wald, and the Fichtel Gebirge, is continued by those two giant volcanos of Bohemia, now in their ruined state constituting the Duppaner Gebirge and the Leitmeritzer Gebirge, the latter of which is cut through by the Elbe. Again following an inflexion of the great Alpine axis, and crossing the lateral range of the Carpathians, we reach the Hungarian series of volcanos, and recognize the evidence of gigantic Miocene cones or groups of cones in the mountains of Gran and Visegrad, the district around Schemnitz, the Matra, the Tokay-Eperies Mountains, the Vihorlat Mountains, the Hargitta Mountains, the Transylvanian Erzgebirge, and the volcanic districts of the Banat of Hungary and Northern Turkey. In the southern extremity of the Crimea, in the Caucasus, and in the volcanic rocks forming the southern extremity of the Oural, we trace the extension of the same line of Miocene volcanos till it is finally lost in the mists that still enshroud the geology of Central Asia.

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[1] Mr. Major has shown that there is ground for believing that a series of old rocks mentioned in some old sailing directions as existing midway between Iceland and Greenland, and called Grumbjorns Skerries, were blown up by a volcanic eruption in *1456*, and long after that date formed a reef which has since diminished greatly in height. Here then we probably have another relic of this submerged chain of anic peaks.

The greater oscillations, attended with the more sweeping action of marine denudation, which have affected the southern range of Miocene volcanos,—those north of the Alps having for the most part suffered only from subaerial waste,—has resulted in reducing the former to a much more ruinous condition than the latter. In the numerous intrusive masses of gabbro, serpentine, diorite, etc., which abound in the Iberian and Italian peninsulas, and which are, in many cases at least, of post-Eocene age, as well as in some skeleton volcanos, like those of the Euganean Hills and Styria, with vents like those of Sardinia, Central and Southern Italy, Sicily, and the Ægean Sea, which have continued in action to more recent periods, we find the different centres of volcanic action on the southern side of the Alps, exhibiting every stage of dissection by denudation. This southern chain is continued eastwards by the volcanos of Asia Minor, Persia, and Afghanistan into Northern India.

The extinction of the great volcanic cones, both on the north and south sides of the central mountain axis, was followed, as we have already remarked, by the appearance of scattered "puys" which can be reckoned by thousands, and were evidently thrown up along lines of fissure opened in the plains surrounding the extinct cones.

It is impossible to regard as accidental the close agreement which we have thus shown to exist between the critical periods in the history of the last great movements in the Alpine axis, and those of the volcanic outbursts in the surrounding areas; more especially as we have seen that the igneous activity was developed along lines having the most unmistakable parallelism to the principal Alpine chains.

Now it is of the very highest importance that we should fully recognize the vastness of the changes which have taken place in the physical geography of the continent during a comparatively recent geological epoch: for in the action of the great subterranean movements during the later Tertiary periods we can scarcely fail to recognize—if the amount and effects of the disturbances be fully realized—a competent cause for some of the more important of the physical phenomena that mark the history of this epoch in Western Europe; and among these we may especially mention that extension of the Alpine glaciers, which seems to have characterized several of the most recent of the geological periods.

In seeking for the causes of the extension of glaciers during former geological periods, we cannot but regard it as a most unfortunate circumstance that geologists have often appealed for explanations of the phenomena they witness to the little-known and less-understood action of the ice-fields that are supposed to cover Greenland and the Antarctic continent. Hence has grown up the hypotheses of vast movements of "continental ice," of "ice-sheets," and "polar ice-caps," the very existence of which rests on the smallest and slenderest basis of evidence. For the supposition that the icebergs of Arctic regions are not derived from large and confluent glaciers, but from detached portions of ice-sheets which have the power of over-riding hill and valley alike, I must confess myself to have failed to find a particle of proof in any of the works describing the results of polar explorations.

If, instead of speculating on what is going on beneath these imaginary "polar ice-caps," we turn our attention to a country which affords the grandest illustrations of glacial action in the world—I refer to New Zealand—and which has had the advantage of having been thoroughly explored by such competent observers as Hector and Hochstetter, Haast and Hutton, not to mention many others, we shall, I think, be led to frame opinions on the subject which have the advantage of being more in harmony with all the facts observed, both physical and palæontological.

New Zealand is situated some five degrees nearer to the equator than are the Alpine regions of Europe; yet, during very recent periods in the world's history, the former district was subjected to glacial action on the grandest conceivable scale, the remaining monuments of which are of the most striking and unmistakable character. Even the shrunken relics of those glaciers which still remain are of a magnitude which make the existing Alpine glaciers appear puny by comparison; one of them extending to within 500 feet of the sea-level, in the midst of a country covered with tree-ferns and palms.

When these remarkable glaciers and the proofs of their former greater extension were first described, the facts were of course adduced by many geologists as a proof that the whole globe had, during certain periods, been subjected to secular refrigeration; and New Zealand was supposed to afford the strongest possible demonstration of the existence of "the Glacial Period." But the careful study of all the evidence, especially the palæontological, has compelled the whole of the distinguished geologists we have named above to entirely renounce their former views upon the subject, this reform in opinion having been led by Dr. Hector in 1863. The fossil shells belonging to the whole series of Tertiary and post-Tertiary deposits prove conclusively that no such changes of climate as are argued for by advocates of universal Glacial periods ever took place in the Southern hemisphere; and these conclusions of the New Zealand geologists are fully supported by those arrived at by Professor M'Coy in Australia.

Nor are the palæontological facts pointing to the same conclusion in the case of the Northern hemisphere less convincing. It has been argued from the existence of large blocks, and the poverty of the fauna in certain sub-Alpine deposits, that "glacial epochs," or a general refrigeration of climate in the Northern hemisphere, occurred both in the Eocene and Miocene periods. We shall not stay to point out how cautiously the presence of merely transported blocks—not exhibiting any glacial striation—should be accepted as evidence of glacial action, in the face of the facts which have been published by Mr. Drew concerning the composition of the "fans" of the Himalaya. But, assuming that an extension of glacial action did take place in the Alps during the Eocene and Miocene periods respectively, that these "glacial periods" were of purely local and not of universal character, we have the most complete proofs which it is possible to conceive.

As was so well pointed out by Mr. Searles Wood, we find in the Hampshire and Paris basins the most beautiful and perfect illustrations of the whole series of Eocene and Oligocene deposits at a number of points, *situated more than ten degrees nearer the pole* than the Alpine regions; and yet in these, not only are we met by the fact of the absence of even the smallest trace of the physical action of glaciers, but, as every student of the British, French, and Belgian Tertiaries is well aware, there is not a particle of evidence in favour of such dwarfing of certain species, accompanied by the migration and extinction of others, which could not fail to accompany the extension of the supposed polar ice-caps during parts of those periods.

Again, in the case of the Miocene, we have in the Vienna basin a complete series of deposits formed in the same latitude with the Alps, which exhibit in the characters of their faunas clear evidence of a gradual passage from tropical, through sub-tropical, to the temperate conditions of the adjoining seas, but no trace whatever of any such interruption as could not fail to have been produced by a period of excessive cold.

I need scarcely refer to the supposed existence of a "Glacial period" during Jurassic times, for the evidence of which my own observations in Sutherland have been again and again quoted, in spite of the numerous facts which, as I have myself pointed out, militate in the strongest manner against any such hypothesis.

To the readers of this MAGAZINE, too, it will be unnecessary to recall the important verdict pronounced by Professor Nordenskiöld, after his long and careful examination of the geological deposits of the Arctic regions, where surely, if anywhere, evidence in support of the alternation of glacial and mild periods ought to be observed. He declares that "from Palæontological science no support can be obtained for the assumption of a periodical alternation of warm and cold climates on the surface of the earth."

Nor is the evidence against the universality of glacial periods wholly derived from Palæontology. The general absence of recent marks of glacial action in Eastern Europe is well known; and the series of changes which have been so well traced and described by Professor Szabó as occurring in those districts seems to leave no room for those periodical extensions of "ice-caps" with which some authors in this country have amused themselves and their readers.

Mr. Campbell, whose ability to recognize the physical evidences of glaciers will scarcely be questioned, finds quite the same absence of the proof of extensive ice-action in North America, westward of the meridian of Chicago.

In the face of all these facts, it is impossible to avoid the conclusion that the so-called "Glacial Epoch" was a *purely local* phenomenon, confined to Western Europe and Eastern America, and that earlier extensions of glacial action were equally due to local causes.

Hence we are altogether spared the necessity of discussing such hypothetical explanations for secular changes of climate as have been advanced by Croll, Belt, Drayson, and others; seeing that not only are there no facts calling for the aid of any such hypotheses, but that the conclusions of both the palæontologist and field-geologist point in quite a different direction. We are far from regretting the publication of those charming works which have lately treated geological questions on the hypothesis of the occurrence of a rhythmical succession of hot and cold periods during the earth's past history. Yet we cannot help thinking that, had their authors paid a little more regard to the established results of palæontological investigation, each of the works in question might have been presented to the public in the form of three thin volumes rather than as a single bulky one.

The distinguished geologists of New Zealand, to whom we have before referred, on finding that the hypothesis of a great reduction of temperature in the Southern Hemisphere was quite untenable, began to search for other causes to which the former extension of their glaciers could be referred. Such a cause they believe themselves to have discovered in the demonstrated former existence of widely extended tracts (now reduced to narrow ridges only by denudation) above the snow-line, and the maintenance of these vast gathering grounds for glaciers during enormous periods of time, by the subterranean movements that have so greatly affected New Zealand.

Have not precisely similar causes been at work in the case of the Alpine district, and are not the phenomena of the former extension of glaciers in that area far more in accord with such a cause, as we have just referred to, than with the hypothesis of alternations of climatal condition, due to astronomical causes—even supposing that these were not so distinctly negatived by palæontological evidence? Since the incubus of the Universal Deluge was got rid of by geologists, no hypothesis more obstructive to the development of their science has appeared, than the doctrine that the existence of ice-action in a district is a proof of secular refrigeration of climate.

Of the various cosmical causes so ably discussed by Mr. Searles Wood in recent numbers of the GEOLOGICAL MAGAZINE, we may readily grant that one or more may have contributed in some degree to the production of variations in climate during past geological times; but, until the effects of those local changes of level which we know to have occurred have been fully taken into account and proved to be inadequate in each special case, it is surely very rash indeed on the part of geologists to appeal to agencies, of which the origin and effects are confessedly so little understood. And while it is scarcely possible to assign a limit to the size which glaciers might attain—if supplied from feeding grounds of sufficient elevation and extent, on which a large amount of precipitation was constantly taking place—it is very difficult indeed to understand how a simple reduction of temperature should produce the effects which are so constantly assigned to it by some writers.

In the case of the Alps I know of no glacial phenomena which are not capable of being explained, like those of New Zealand, by a great extension of the area of the tracts above the snow-line, which would collect more ample supplies for the glaciers protruded into the surrounding plains. And when we survey the grand panoramas of ridges, pinnacles and peaks, produced for the most part by subaerial action, we may well be prepared to admit that before the intervening ravines and valleys were excavated, the glaciers shed from the elevated plateaux must have been of vastly greater magnitude than at present. This increase of the area above the snow-line, resulting in the extension of the glaciers, would likewise follow from the elevations of the whole mountain mass; and the same movement would also account for the transport of blocks across the wide Swiss valley, and their lodgement on what are now opposing slopes. It is an interesting confirmation of these views that the Western Alps, where the subterranean action has been most violent and prolonged, is also the district in which the glacial action has been most powerfully marked.

We need scarcely add that, if these views be correct, there is no necessary connexion, either in their period or in their cause, between the extension of glaciers in Northern Europe and the Alps respectively. The identification of the two series of events rests indeed on no sufficient palæontological or physical evidence.

I have not in this article attempted to deal with the remarkable phenomenon of the prevalence of more uniform climates over the whole globe during past geological periods, the admission of which, as Dana and Nordenskiöld have so well pointed out, it is hardly possible to avoid. This is perhaps the most difficult problem which geologists are called upon at the present day to face. Possibly the results of the Arctic Expedition, when fully worked out, may throw some new light on this important question.

If, in the series of articles which we are now bringing to a close, we have been led to dwell at greater length upon the proofs of subterranean action, than upon those more obvious results due to the operation of external forces upon the earth's crust, it is with no desire to under-estimate the importance of the latter, but rather with a view to counteract the somewhat one-sided statements that have been made concerning the relative effects of the two classes of terrestrial forces.

Prof. Geikie and Mr. Croll have done excellent service to geological science in reviewing and calling attention to the results of estimates of the amount of waste produced by subaerial denudation, and the rate at which the surfaces of our existing continents are being worn away. Fully agreeing with Prof. Hughes that, as actual measures of geological periods, such estimates are open to so many sources of error and are so difficult of application as to be worthy of but little reliance, we nevertheless regard them as having a very great value in enabling us to appreciate the reality and the important effects of operations ever going on insensibly around us.

We venture to think that still further uses may be served by these same estimates, in giving us the means of realizing the amount of work effected by those subterranean forces, the results of the operation of which are even less easily detected than those of subaerial waste.

That the ordinary processes of the earth's economy have been maintained in constant operation throughout a long succession of geological periods we have the clearest proof. And, as a necessary consequence of this, we are bound to conclude that something like the same *general balance* between the elevated and submerged areas of the earth's surface has been preserved during those periods.

Now nothing comes out more clearly from the ingenious estimates to which we have referred than the conclusion that—in a period of time of comparatively short duration, geologically speaking—the whole of the existing continents would be washed away, and their materials deposited on the bed of the ocean by the action of the agencies of waste and transport now in operation—were these destructive forces not counteracted by the constant elevation of portions of the earth's crust.

Assuming then, as we have seen there are good grounds for doing, that the general balance between land and water has been maintained during very long geological periods—the subterranean movements of the earth's crust, if all in the direction of elevation, would produce effects that would be exactly represented by the total effects of subaerial and marine waste during the same period.

But seeing that a large amount of the effects of elevation must of necessity be neutralized by those of depression, we are forced to conclude that the results produced by subterranean are *far greater* than those brought about by surface denudation. That, indeed, the results of the latter are actually compensated by the excess of the elevatory movements over those of subsidence.

To enable us therefore to establish anything like an actual relation between the work performed by subterranean and surface forces, in modifying the earth's crust, we should require to obtain a measure of the effects of movements of depression. Here Mr. Croll's calculations, based on the thickness of the sedimentary rocks, may be of some use, for, as Mr. Darwin has so well shown, the stratified rocks must almost without exception have been deposited in subsiding areas, and the thickness of the rocks thus becomes a measure of the amount of subsidence that the areas on which they were deposited have undergone. But as many areas are undoubtedly subsiding, without receiving sediment at all, even this will only give an unknown fraction of the quantity required.

From all these considerations then we are driven to conclude that the work performed by surface agencies, in modifying the forms of the earth's crust, vast as it is, bears but a very small, though indeterminable, proportion to that effected by the subterranean forces.

THE END.

II.—ON THE GLAUCONITIC GRANULES OF THE CAMBRIDGE GREENSAND.

By W. J. SOLLAS, B.A., F.G.S.

(PLATE XXI.)

THE Coprolites or phosphatic nodules of the Cambridge Greensand frequently contain amongst other included bodies a number of Foraminifera and glauconite granules, of the same kind as those found scattered loosely throughout the Greensand bed.

When a transparent slice is prepared of one of these coprolites, it of course reveals a number of these included bodies in section, and so offers a favourable opportunity for the examination of their internal structure, an opportunity which I have made use of, especially with a view to test the conclusions which I had published in 1872 on the origin of the Greensand glauconitic grains.

Position of the Green Granules and Foraminifera in the Coprolites.—These, like most of the other foreign bodies contained in the phosphatic nodules, occur most usually and in greatest abundance in the secondary deposit of coprolite, which has, subsequently to the formation of the original nodule, incrusted its surface or filled in the cracks that fissured it as it contracted on fossilization; while in those nodules which owe their origin to sponges these included bodies are found, in addition to the former positions, in the material which has entered into and filled up what were once the canals and 'cloaca' of the sponge.

Foraminifera.—These are arenaceous and perforate vitreous forms, like those which occur in the Greensand bed; their chambers are filled with different materials in different cases, sometimes crystalline calcite, and occasionally glauconite has infiltrated them, but most commonly phosphatic material similar to that in which they are contained. These three minerals are found in the interior indifferently of both arenaceous and perforate foraminifera; and when glauconite fills the latter, it may be traced from the cast of the chambers passing into the fine tubulations which perforate the walls.

Green Grains. External Form.—Some of the green grains are of the regular shape which characterizes casts of perforate Foraminifera; but the majority of the sections are of such various and irregular outline, that from it alone no clue to their mode of origin can be obtained; of these irregular forms a few exhibit attached to their exterior fragments of arenaceous foraminiferal tests, the remnants probably of the moulds in which they were formed; but the greater number are free from any such incrustation, and are simply granules of glauconite of very irregular form. What the origin of these may be is very doubtful; judging by analogy it seems probable that many of them may be casts of arenaceous Foraminifera; but how far this is actually the case we have no means of saying.

Internal Structure.—The thin sections of the glauconite granules are of a light green colour, deeper in tint in some places than others, and transparent except where rendered opaque by the presence of included particles.

The substances usually scattered throughout the sections are small Foraminifera, Coccoliths, Coccospheres, minute granules, fragments of crystalline minerals, and other substances, the nature of which is uncertain.

Foraminifera.—These are very small, and in proportion to the size of the granule containing them absolutely insignificant (Pl. XXI. Fig. 1*f.*). The walls of their tests are either well preserved as pseudomorphs in glauconite, in which case they are of the same green colour, but clearer and more transparent than the surrounding material, and well defined on both their inner and outer margins; or else they have disappeared altogether or in part, leaving only a few granules or a dark brown line to mark their original position.

The position of the Foraminifera in the green grains is very variable, sometimes a test may be seen in the middle of a section (Pl. XXI. Fig. 3 *f.*), but quite as often at the side (Pl. XXI. Fig. 1 *f.*); whilst in one instance (Pl. XXI., Fig. 2*f.*) the outline of the grain intersects the inclosed Foraminifera, cutting off the interior from an exterior portion which has since disappeared. The intersecting edge of this grain (*l.*) is, however, a suspiciously straight one, and may possibly be due to fracture.

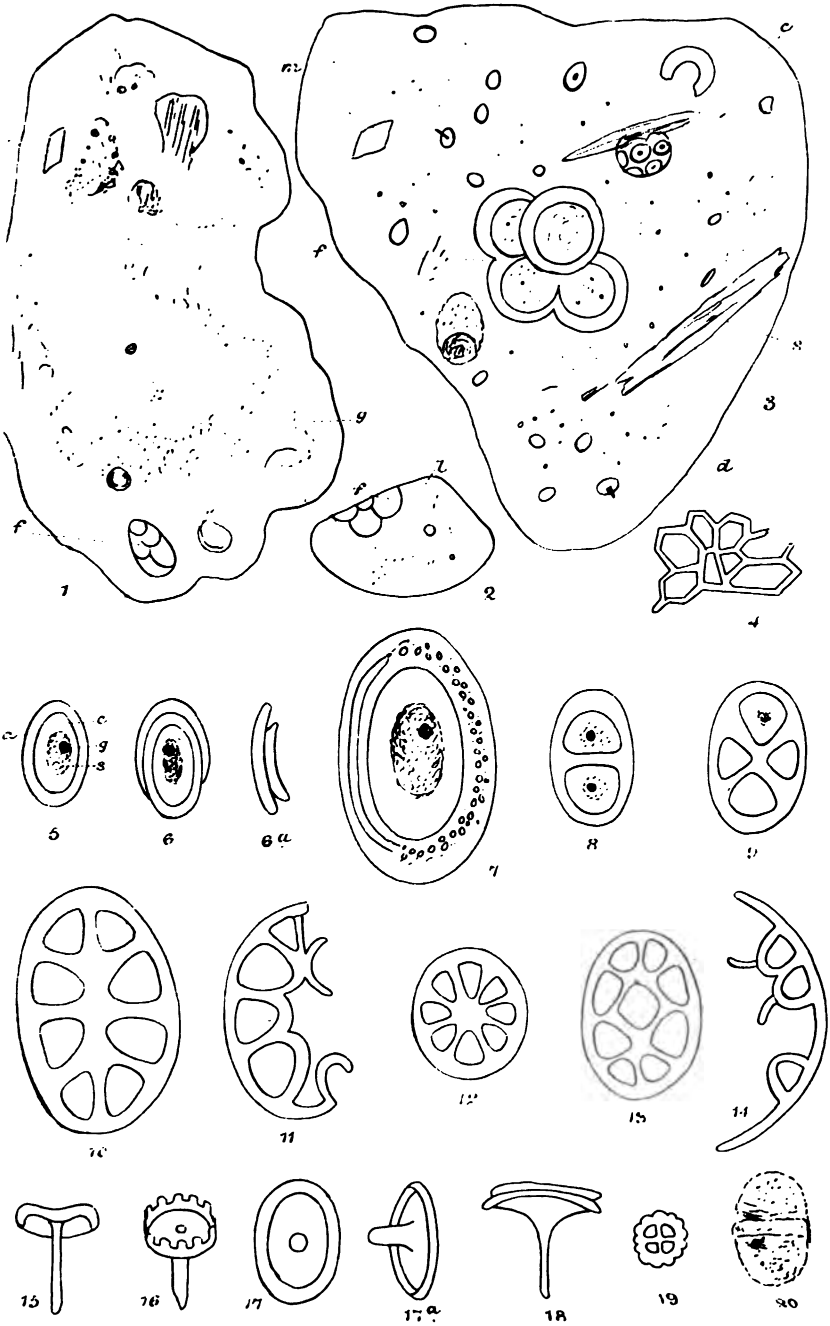
No appearance of a crystalline radiation from any of the included bodies towards the circumference of the granules is to be detected either with ordinary or by polarized light.

Coccoliths.—The Chalk-marl, which constitutes the greater part of the Cambridge Greensand bed, is to a great extent composed of coccoliths, entire and fragmentary, which in the number and variety of their forms surpass all that I have yet seen figured from recent seas. I have already drawn, and partly described, a large series of these bodies; but as it will be impossible to publish the description for some time, and as their presence in the glauconite granules is a subject which concerns us now, it may not be amiss to give a brief preliminary account of the forms which have been recognized in the granules, supplemented by the addition of one or two others from the Chalk-marl.

The form represented in Pl. XXI. Fig. 5, is one of the most abundant in the Chalk-marl, and occurs most commonly in the glauconitic granules. It consists of a transparent, colourless or faintly greenish oval ring (Fig. 5*a.*), well defined on its outer and inner circumference, inclosing an oval space, clear and transparent (*c.*) at its outer margin, close to the inside of the ring, but cloudy and granular (*s.*) towards the centre, at or near which is situated a single granule (*g.*), larger than the rest, transparent and of the same green tint as the outer annulus. Viewed sideways this form appears like a simple rod.

The whole of this structure consists of carbonate of lime, and on solution in weak acid dissolves entirely or with the exception of a delicate membranous film, which is dotted over with a number of faintly marked granules; and which on the addition of carmine or magenta stains to a light red colour. Fig. 20 represents such a film left on the solution of a form like that shown in Fig. 8.

GEOL. MAG. 1876. NEW SERIES. DECADE II. VOL. III. PLATE XXI.



J. Sollas del. W. West & Co.

Glauconitic granules from the Cambridge Greensand

This membrane may be composed of sulphate of lime, which has impregnated the calcareous skeleton of the coccolith after its death, though I doubt this.

The form we have just described is evidently a flat or somewhat concave disc, thickened at its edges into a ring-like border, and at its centre into a granulated area with one of the granules much larger than the rest. It is well enough preserved in the glauconitic granules to show clearly the outer annulus and the central granule.

Figs. 6 and 6 *a.* represent a very common modification of this form, which appears to me to result from a circumferential constriction round the edge, grooving it, so as to produce a resemblance to a pulley-wheel. It has not been observed within the green grains. Fig. 7 is a large form of Fig. 5, which attains relatively to the latter form a size fully double that which is shown here. The outer ring much thickened appears to be marked along the middle of its upper margin by a rounded ridge, which on focussing down resolves itself into a number of granules, somewhat irregularly arranged. Broken pieces of this variety are to be seen in the green grains.

The next form, Fig. 8, is similar to Fig. 5, but differs from it by the presence of a transverse bar produced from the annulus, along the minor axis of the ellipse, and which divides the central oval area into two parts, each with its cloudy centre and refractile granule.

To all appearance this is simply Fig. 5 undergoing fission, and yet the whole structure consists of carbonate of lime. In connexion with this, it is noticeable that while both of these coccoliths vary in size, yet that of Fig. 5 does so to a much greater extent than that of Fig. 8.

In the next variety, Fig. 9, the process of sub-division has gone a step further, and the space within the ring is partitioned off into four by a thickening of the disc along two axes at right angles to each other.

The next division of the coccolith is into eight, as shown in Fig. 10, and so far each step in the process has followed the geometric progression, 1, 2, 4, 8; in Fig. 13, however, we have an exception to this rule, since it exhibits nine sub-divisions within its nclosing annulus, and we omitted in passing to notice another very rare form where the loculi number three. Fragments of the forms Figs. 10 and 13 are found in the Chalk-marl (Fig. 11) looking like a residue left on the dehiscence of the other part of the coccolith; such a fragment (Fig. 14) is the only instance of these last complicated forms which I have observed in the green granules, and it appears to have been derived from an even still more complex type, since f the missing part be supplied, the restored ring would present, I hould judge, nearer 16 than 8 loculi. All the forms from Fig. 5 to 3 vary in the relative length of their major and minor axes, and ometimes become quite circular; Fig. 12 represents the round ariety of Fig. 10.

All again may develope stalks or stems at right angles to the plane f the disc, *e.g.* Fig. 15, which is derived from a form like Fig. 5; ig. 17 *a,* from Fig. 17; and Fig. 18 from Fig. 6. In forms like Figs.

8, 9, 10, the stalk is produced from the centre of the transverse thickening; of these stalked varieties only forms like Fig. 15 have been observed in the green grains. (See Pl. XXI. Fig. 3 *d.*)

Fig. 19 is a variety of Fig. 9, differing from it by its granulated edge; Fig. 16 is a stalked form, granulated sharply on its upper margin, so as to resemble a crown-wheel.

Coccospheres.—These I have observed in several instances in the Chalk-marl as spherical bodies covered loosely with the oval form of coccolith like Fig. 5. On solution a faint granular membrane corresponding in outline and size with the original sphere remains behind; it stains faintly with magenta. In the glauconitic granules I have several times noticed small spherical bodies with thin walls, marked with refractile ridges and granules, which closely resemble coccospheres; the best marked of these is shown in Fig. 3 at *c.*

Granules.—These bodies, which are exactly similar in size and appearance to those which make up so large a proportion of the Chalk-marl, and which resemble also the refractile granules inside the coccoliths, occur very abundantly in the green grains, and can be distinguished therein by their greater transparency and different refractive index.

Bodies of uncertain nature.—Small angular fragments of colourless and transparent crystalline minerals resembling felspar, splinters of an indeterminate substance, bacilli and other small bodies, are sometimes inclosed. One green grain $\frac{1}{40}''$ diameter was observed to be entirely filled with a faintly defined, fine, polygonal reticulation, a part of which is shown, magnified 435 diameters, in Fig. 4. What this may be it is hard to say; but clearly the organism from which the grain was derived had no connexion with the Foraminifera.

Conclusion.—The coccoliths and granules which characterize the green grains of irregular form, are also present in the glauconite casts of foraminiferal chambers, and in the phosphatic material and crystalline calcite, which occupy the interior of the foraminiferal tests; while all the bodies described from the interior of the granules occur also in the phosphatic matrix of the coprolite which imbeds both the foraminifera and the green grains, and in the Chalk-marl which contains the coprolites. The character, in fact, of the irregular granules and of the foraminiferal casts is that of Chalk-marl, which has become changed by a mineral replacement into glauconite. What the cause is which has induced this change is another question, but apparently the presence of organic matter in some form or other has been essential to it; thus we frequently find glauconitic material forming a cast of the interior of a foraminifer and infiltrating its tubules, without in the least affecting its calcareous walls, which retain their original composition. It here then occupies the place of animal matter to the total disregard of the associated mineral shell. To this it may be objected that the glauconite may also be regarded as occupying a space separated from the external Chalk-marl by a limiting foraminiferal test, and that the presence of this separation was sufficient to bring about the infiltration which has taken place; but if this view be true, one would expect to find some trace of a rogressive growth in the glauconite from the exterior inwards, rhile in fact no signs of any such increase can be detected, neither n successive incrustations, nor in any crystalline arrangement, like hat which one observes when a mineral infiltration has really taken lace in this stalactitic manner.

The glauconite is indeed not crystallized, but simply cryptocrystaline, in exactly the same way as flint and coprolite are cryptorystalline. Accepting then, as seems to be generally allowed, that he presence of animal matter has been one of the essential deternining causes for the deposition of glauconitic material, we have ext to find animal matter for this purpose. The inclosed Foramiifera seem too minute to have furnished a sufficient supply, nor ave they been proved to be constantly present in the granules, specially since the sections of many of the latter show no signs of hem; it thus appears that we must have recourse to the agency of uch minute and soft-bodied organisms as are to be found amongst the Protista and Protozoa; these scattered throughout the Chalk-marl in vhich the green grains were originally formed would, on their leath, lead to a deposition of glauconite about themselves, and thus ecessarily include the immediately adjacent Foraminifera and occoliths, and the other bodies which they now contain; while the hape of the resulting glauconitic mass would be simply determined y the irregular extension of the decaying organic matter.

The resemblance of the glauconitic granules to flints and coproites, which appears on this view, is very striking. Both flints and oprolites are found filling the interior of certain shells, most notable nstances of which are the coprolitic casts of *Pleurotomaria*, and the lint which fills the interior of *Ananchytes;* both frequently surround, ven to the extent of inclosing, the organisms, which at other times hey simply occupy as casts; and both also have served to mineralize he soft animal matter furnished by various kinds of sponges; the glauconitic granules similarly are frequently confined to the interior f foraminiferal tests, from which, however, they sometimes extend o as to spread over the exterior and form a complete inclosure, vhile finally, according to our view, they present a further analogy in that they have also formed about the soft bodies of decomposing nimals, of the previous existence of which they now supply the nly trace.

EXPLANATION OF PLATE XXI.

Fig. 1. Section of a glauconitic granule, magnified 140 diameters; (*f*) included Foraminifer; (*g*) granules; (*m*) fragment of crystalline mineral.

Fig. 2. Section of a glauconitic granule, including a part of a Foraminifer (*f*); the rest of which is cut off by the edge (*l*). (× 140.)

Fig. 3. Section of a glauconitic granule, magnified 435 diameters; (*d*) coccoliths; (*c*) coccosphere; (*s*) splinter of uncertain nature. The other letters as in Fig. 1.

Fig. 4. Part of the polygonal reticulation of which one of the green granules is composed. (× 435.)

Fig. 5. Simple form of coccolith; (*a*) the outer annulus; (*c*) the clear zone; (*s*) the clouded central area; (*g*) the central granule.

Fig. 6. Coccolith with marginal grove, seen face on, but slightly tilted at one end; (6 *a*) side view of the preceding.

Fig. 7. Large form of simple coccolith, showing superficial ornamentation of the annulus.
Figs. 8 to 13. Coccoliths exhibiting the successive stages in which the central area becomes subdivided.
Fig. 14. Fragment of a complex coccolith included in a glauconitic granule.
Figs. 15 to 18. Various stalked forms of coccolith.
Fig. 19. A variety of Fig. 9, granulated at the margin.
Fig. 20. Membranous film left after the solution of a form like Fig. 8.
Figs. 5 to 20 are magnified from 1500 to 2000 diameters.

III.—On Scottish Monograptidæ.

By Charles Lapworth, F.G.S.

(Concluded from page 507.)

§ VIII.

Genus Cyrtograptus, Carruthers.

This genus was founded by Mr. Carruthers to include those compound forms of monoprionidian *Graptolites* in which the polypary is unilateral, growing from the initial point in one direction only. There can be no hesitation in regarding it morphologically as a branching *Monograptus*; its mode of development, the characters of its hydrothecæ, and its geological distribution, all pointing unmistakably in this direction. It is also very variable in its mode of branching; and occasionally simple examples are met with, undistinguishable in every respect from typical specimens of *Monograptus*. This negative evidence is, however, of no great weight, as these examples previous to fossilization may have been deprived of the branches they once possessed. Unlike *Monograptus*, the species of this genus are few in number, and even individuals are of rare occurrence. Recollecting, however, the fragmentary state in which all the forms of the present family are preserved to us, and the impossibility of identifying a species of *Cyrtograptus* unless we possess unequivocal evidence of the compound character of the polypary, it may be regarded as certain that our present scanty list will be greatly augmented in the future.

35. Cyrtograptus Carruthersi, sp. nov. Plate X. Figs. 6*a*-*c*.[1]

Polypary unilateral, compound, monoprionidian. Principal branches long, slender and flexuous, originating similar secondary and simple branches at distant intervals. Hydrothecæ 16 to the inch: conical, adnate, in contact only; apertural margin of each inclined: denticle mucronate, conspicuous.

The principal branch exhibits the peculiar circinate proximal termination so frequent in the allied genus *Monograptus*, and is more or less curved throughout the whole of its extent. Extremely slender at its origin, it almost insensibly expands to the normal diameter of one-twentieth of an inch, including the projection of the hydrothecæ. As a rule the polypiferous margin is that of the outer edge of the curve, but great irregularity in this respect is caused by the frequent entanglement of the secondary branches. These exactly resemble the primary branch in size, length, and amount of curvature, but appear to be invariably simple.

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[1] See Geol. Mag. for July, p. 321.

The hydrothecæ are of the type of those of *Monograptus Nilssoni*, Barr. They are very widely set and just touch each other at their extremities. Each is of the general form of an inverted cone, and is pressed flat against the margin of the periderm. The outer edge of each is straight and makes an angle of about 30 degrees with the axis of the branch. The apertural margin is usually much inclined, so that the denticle is distinctly acute. It is occasionally prolonged in a slender spine.

Fragments of *Cyrtograptus Carruthersi* are easily distinguished from those of *Monogr. Nilssoni*, which occurs upon the same horizon, by the size, shape, and number of the hydrothecæ.

I dedicate this striking form to Mr. Wm. Carruthers, F.R.S., the founder of the genus, to whom I am greatly indebted for assistance in my work among the Graptolites.

Locality.—Riccarton Beds of Elliotsfield, Shankend, Riccarton, Mosspaul.

36. Cyrtograptus Grayi, sp. nov. Plate XX. Figs. 11 *a*, 11 *b*.[1]

Polypary unilateral, monoprionidian: branching and re-branching. Branches slender, flexuous, distant. Hydrothecæ 20 to the inch; slender tubes, the earlier portion of each closely adpressed to the periderm; distal portion isolated and partly coiled up into a rounded lobe.

Although fragmentary examples occur in abundance in one locality in the Girvan district, our knowledge of this species is yet far from being complete. I figure the most perfect specimen hitherto detected (Plate XX. 11 *a*). The principal branch is short, much curved and of great tenuity. The secondary and tertiary branches are long and flexuous. Their diameter, including that of the hydrothecæ, never exceeds one-thirtieth of an inch. The latter are of the type of those of *Monogr. lobiferus*, M'Coy; and, as in many of the species of the group typified by that form, the free lobed portion increases in extent as the polypary grows in length. In the earlier portion of the primary branch the free portion is scarcely perceptible; while in the better developed portions of the tertiary branches at least half the theca is isolated and the lobe is rounded and very conspicuous.

This species is named after its discoverer, Mrs. W. Gray, whose unequalled collection from the Silurian rocks of Girvan has already been of such signal service to science.

Locality.—Girvan beds, Ayrshire, at Penwhapple Glen; Gala Group at Yair, Elwand?

§ IX.

Dimorphograptus, gen. nov.

Gen. Char.—*Polypary originating from a persistent adherent sicula; proximal portion monoprionidian; distal portion diprionidian.*

Pending the complete elucidation of their structure and affinities, I propose to unite provisionally under the foregoing title some very remarkable fossils of rare occurrence in our Scottish rocks, which appear to unite in themselves the characteristics of two distinct *Graptolitic* families. In these anomalous species the cœnosarcal tube originates from a point on the lateral margin of the sicula a little removed from its broader extremity, adheres to it by the proximal portion of its dorsal wall, and is prolonged beyond it in the same general direction, exactly as in every species of the *Monograptidæ* whose development has been thoroughly investigated. But, after the cœnosarc has developed a few hydrothecæ, it suddenly subdivides, and forms two branches, which grow side by side at a tolerably equal rate, adhere to each other throughout their whole extent by their flattened dorsal walls, and give to the distal portion of the polypary the identical structure and appearance of that of *Diplograptus*.

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[1] See Geol. Mag. for Nov. p. 507.

Guided more especially by the appearances successively presented by the sicula and polypary in the earliest stages of development in *Cenograptus*, Hall, and its allies, I formerly advocated the view that the sicula in all the bilateral genera threw out two buds—one from each of its opposite lateral margins; and, by analogy, extended it to include adherent forms like *Diplograptus* and *Climacograptus*. There is, however, another theory; which, though it may appear at first sight totally irreconcilable with the successive phases of the budding polypary in some forms of the *Diplograpti*, is far simpler, and in all likelihood will prove to be the true one. According to this theory the sicula in *all* the *Graptoloidea* throws off a single bud only, and thus theoretically invariably originates a single cœnosarcal tube. In *Tetragraptus* and its allies,[1] this first-formed cœnosarcal tube (pro-cœnosarc) is divided immediately at its origin into two branches, and again subdivided within a very short distance. Between the proximal ends of the two pairs of primary branches which commence at these subdivisions, there is thus formed a short horizontal bar, never more than one-fourth of an inch in length, totally barren of hydrothecæ, and having the sicula in its centre. This is the true *funicle* of Hall, and evidence has recently been obtained which makes it certain that, contrary to the general belief hitherto, this is the only non-polypiferous portion of the polypary in any of these highly complex genera. Making exception of the genus *Phyllograptus*, Hall (which is morphologically a *Tetragraptus* with coalescent branches), there is no secondary subdivision of the non-polypiferous portion of the cœnosarcal canal in any of the remaining *Graptoloidea*. In *Diplograptus*, *Pleurograptus*, etc., it is once divided immediately after origin. In *Monograptus* and its allies it is not divided at all.

Hence we may look upon *Dimorphograptus* either as a *Diplograptid* in which the division of the cœnosarc is deferred till several hydrothecæ have been developed; or as a *Monograptid* (like *Cyrtograptus*), whose branches, instead of being free, are wholly coalescent.

The discovery of this genus lends additional support to the theory that the *Monograptidæ* are the direct descendants of the *Diplograptidæ*, and not of any of the compound monoprionidian genera. The latter view of their origin, though extremely natural, has always had two difficulties in the way of its acceptance; viz. the distinct isolation of the sicula in those genera, and the fact that they appear all to have become extinct long prior to the advent of the first of the *Monograptidæ*. In the *Diplograptidæ*, on the other hand, the sicula is adherent, and individuals swarm abundantly in the same beds with the *Monograptidæ*.

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[1] *Clonograptus*, Hall; *Clematograptus*, Hopk.; *Loganograptus*, Hall, etc.

On this view of the relationship of the two families, we may set down the coalescence of the branches in *Dimorphograptus* to partial reversion. To the same cause may perhaps be ascribed the bilateral character of the polypary in the abnormal examples of *Monograptus runcinatus*, etc.

37. DIMORPHOGRAPTUS ELONGATUS, sp. nov. Plate XX. Figs. 12*a*–*b*.

Polypary one and a half to two inches in length; proximal portion monoprionidian, slightly recurved, slender and tapering; distal portion diprionidian, expanding to a maximum width of one-twelfth of an inch. Virgula distally prolonged. Hydrothecæ 20 to the inch; making a small angle with the axis of the polypary; long, slender, without overlap; apertural margin of each much inclined; denticle acute, conspicuous.

The sicula, which is slender and about one-tenth of an inch in length, lies upon the dorsal aspect of the proximal extremity of the polypary, as in *Monograptus*. In some examples there is a short extension of the virgula, directed proximally in the line of the suture between the sicula and polypary. The proximal monoprionidian portion of the polypary has the peculiar dorsal curvature so frequently seen in *Monograptus*. The earlier hydrothecæ are pressed flat against the periderm; the apertural margin of each transgresses for some distance upon the surface of the one which precedes it, and forms a very minute excavation. The latter is shallow, and becomes less and less appreciable as the polypary increases in length. The thecæ themselves are of the general type of those of *Monogr. tenuis*, Portlock, and of those of the *Diplograpti* resembling *Diplogr. tamariscus*, Nich. In the distal portion of the polypary the shallow apertural margin of each, which has previously stood at right angles with the general ventral edge, gradually increases its inclination till finally it makes an angle of about 45° with the axis of the theca, and the denticle becomes long and very acute. This part of the fossil, when found in fragments, is undistinguishable from the corresponding portion of *Diplograptus acuminatus*, Nich., which occurs in abundance upon the same horizon.

Fragments occur in association with this species which seem to be wholly monoprionidian. They possibly belong to this form; as in South Scotland no true examples of *Monograptus* have yet been met with so low in the Moffat Series; but our knowledge of the species is as yet too limited to enable us to determine the point with certainty.

Locality.—*Dimorphograptus elongatus* is a very rare fossil in the lowest zone of the Birkhill Shales at Dobbs Linn and Craigmichan.

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[1] *See* GEOL. MAG. for Nov. p. 507.

38. Dimorphograptus Swanstoni, sp. nov. Plate XX. Fig. 13a–e.[1]

Polypary less than one inch in length; proximal portion monoprionidian, narrow, recurved and having a blunt initial extremity formed by a short stout sicula; distal portion rapidly expanding to a normal diameter of one-eighth of an inch. Hydrothecæ 25 to 30 to the inch, without overlap; making an angle of about 30° with the general ventral margin; outer edge of each concave; apertural edge deep and slightly oblique.

The length of the proximal portion of the polypary varies from one-eighth to nearly one-third of an inch, and the number of its hydrothecæ from three to five. Except in its short and broad sicula, this part of the fossil agrees precisely in all its characters with the earlier portion of *Monograptus gregarius*, Lapw. The hydrothecæ are a little more prolonged in the diprionidian portion of the polypary, and there is occasionally well-marked overlap in the neighbourhood of the distal extremity. Here the apertures are either directly visible, slightly foreshortened, or there is a broad denticle, one margin of which is concave and the other convex. In young examples appears a minute distal prolongation of the very distinct filiform virgula; in adult specimens it is wholly invisible.

Locality.—This well-marked little species has not yet been detected in the South of Scotland; but is here described and figured as strikingly illustrative of this remarkable genus. The specimens figured were forwarded by Wm. Swanston, Esq., of Belfast, to whose cabinet they belong, and who is at present engaged in working outthe Graptolitiferous bands of the North-East of Ireland with remarkable success.

In addition to the forms described in the foregoing pages, there are several distinct South Scottish species of *Monograptidæ* of which only fragments have hitherto been detected. Following out the rule laid down at the commencement of this memoir, I shall defer their description until both extremities of each form have been recognized and its full diagnosis thus rendered possible.

It may be that future investigation will show that some of the forms here classed as varieties ought rather to be regarded as distinct species. Even during the progress of the paper fragments from the distal extremity of *Monograptus convolutus*, His. (=*spiralis*, Geinitz), hitherto identified by its proximal extremity alone, have been detected; and as the thecæ are precisely similar in form throughout the whole extent of the polypary, and thus strikingly different from all those of the remainder of the *Sedgwicki* group, there can no longer be any hesitation in regarding it as a distinct species. It is very doubtful also if *Monograptus dubius*, Suess, can long be retained as a variety of *Monog. colonus*.

On the other hand, *M. Halli*, Barr.; *M. Riccartonensis*, Lapw.; and *M. Flemingii*, Salter, though so strikingly different in their general aspect in the field that no one would hesitate to regard them as distinct species, yet approximate to each other so closely in the form of the theca and its ornaments, that we may eventually be forced to look upon them as being merely successive (chronological) varieties of one and the same species.

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[1] See Geol. Mag. for Nov. p. 507.

VERTICAL RANGE OF THE SCOTTISH MONOGRAPTIDÆ.

ABLE SHOWING THE GEOLOGICAL DISTRIBUTION OF THE SCOTTISH MONOGRAPTIDÆ.

		SOUTH SCOTLAND.						ENGLAND, IRELAND, CENTRAL-EUROPE AND SCANDINAVIA.													
		A.		B.		C.		A.					B.					C.			
		1 Lower Birkhill.	2 Upper Birkhill.	3 Girvan.	4 Gala Group.	5 Riccarton.	6 Low. Pentlands.	7 Coal-pit Bay.	8 Pomeroy.	9 Coniston Mudstn.	10 Sweden (Zone A.)	11 Kiesel Schiefer	12 Colonies.	13 Band E, e. 1.	14 Linda, etc.	15 Tieveshilly.	16 Sweden (Zone B.)	17 Coniston Flags.	18 Wenlock Shale.	19 Band, E, e. 2.	20 Lower Ludlow.
	DIMORPHOGRAPTUS																				
	elongatus, Lapw. ...	x						x													
	MONOGRAPTUS																				
	Sandersoni, Lapw. ...	x						x													
	fimbriatus, Nich. var.	x						x		x											
	triangulatus, Harkn.	x						x	x	x											
	RASTRITES																				
	peregrinus, Barr. ...	x						x		x	x		x	x							
a^1	**MONOGRAPTUS**																				
	leptotheca, Lapw. ...	x	x					x		x		x									
	cyphus, Lapw.	x	x					x		x		x									
	lobiferus, M'Coy. ...	x	x					x		x	x	x									
	tenuis, Portlock	x	x					x	x	x		x									
	attenuatus, Hopk. ...	x	x					x	x	x		x	x								
	gregarius, Lapw.......	x	x					x		x	x		x								
	communis, Lapw. var.	x	x					x		x											
	convolutus, Hisinger.	x	x							x	x		x	x							
	Clingani, Carr.		x																		
	intermedius, Carr. ...		x							x											
	argutus, Lapw.		x							x											
	RASTRITES																				
	hybridus, Lapw.......		x							x		x									
a^2	*maximus*, Carr.		x																		
	capillaris, Carr.		x																		
a^2	*distans*, Lapw.... ...		x		x					x		x									
	MONOGRAPTUS																				
	concinnus, Lapw. ...	x	x	x	x			x		x											
	runcinatus, Lapw. ...		x		x							x				x					
	proteus, Barr.		x		x			x		x		x	x	x	x	x					
	Sedgwicki, Portlk. ...		x	x	x				x	x		x	x								
	Becki, Barr.		x		x					x		x	x	x		x					
	Hisingeri, Carr.		x		x					x	x	x	x			x		?			
B.	*Halli*, Barr.		x	x	x					x		x	x								
	turriculatus, Barr. ...		x		x					x	x	x	x			x					
	exiguus, Nich.........				x					x						x					
	Salteri, Gein.			x	x																
	Galaensis, Lapw				x																
	Barrandei, Suess. ...				x									x		x					
	crispus, Lapw.				x											x					
	priodon, Bronn.				x	x	x						x	x	x	x	x	x	x	x	
	CYRTOGRAPTUS																				
	Grayi, Lapw.			x	x																
	Carruthersi, Lapw.					x	x											x			x
C.	**MONOGRAPTUS**																				
	Riccartonensis, Lapw.					x										x	x	x	x		
	vomerinus, Nich. ...					x	x										x	x	x	x	
	Flemingii, Salter ..					x												x			
	colonus, Barr.					x							x	x	x		x	x	x	x	x
	dubius, Suess.........					x	x										x	x	x	x	x

On an inspection of the foregoing table it is at once apparent that the Scottish Monograptidæ noticed in this paper fall into three well-marked specific groups. The first group embraces those of the Birkhill Shales; the second those of Gala and Girvan; and the third those occurring in the Upper Silurians of Riccarton and the Pentland Hills. The first and second of these groups overlap each other to a large extent—at least half the species of the Gala rocks being survivors from the Birkhill fauna. Remembering the fact that the Birkhill and Gala formations pass almost insensibly the one into the other by a gradual lithological and palæontological transition, this large community of species appears extremely natural. Between the second and third groups, however, there is a decided palæontological break—only two of the Gala forms occurring in the Riccarton Beds. This also is easily accounted for, as the intervening Hawick beds, which would naturally yield the forms common to the two groups, has not as yet afforded any examples of *Graptolites*.

Group A.—In Scotland this group falls into two divisions—the earlier of which is mainly distinguished by the absence of those Birkhill forms which survive into the Gala Group; and by the exclusive presence of *Dimorphograptus elongatus, Monogr. Sandersoni, Monogr. fimbriatus, Monogr. triangulatus,* and the typical form of *Rastrites peregrinus.*

Outside of South Scotland this minor assemblage occurs in its typical form only in the Coal-pit Bay beds of County Down.

The later division contains a large admixture of Gala forms. As yet its only exact foreign representative occurs in the lowest zone of the Upper Graptolite Schist of Sweden.

The forms of Group A, considered as a whole, are met with in abundance in the Coniston Mudstone of the North of England, which ought in all probability to be looked upon as the exact representative of the Birkhill Shale of South Scotland; if, indeed, it be not a portion of the same wide-spreading Graptolitic deposit. As this Coniston Mudstone reposes upon the representative of the Bala Limestone of North Wales, it is probably of Lower Llandovery age. This aids us in fixing the age of the Birkhill Shales, which must thus form the first member of the Scottish Middle Silurian. The same assemblage of species re-appear in the Kiesel Schiefer of Saxony and Thuringia, *i.e.* in the zone of Black Shale upon which reposes the great mass of the Middle Silurian of that district.

Group B.—This embraces the forms found in the great Greywacké Series of the Gala Group, and is made up of several survivors of the Birkhill fauna, some peculiar species, and two or three Upper Silurian forms. The peculiar species include *Cyrtograptus Grayi, Monogr. Galaensis, Monogr. crispus, Monogr. Barrandei, Monogr. exiguus.* Of fossils passing upwards into the Upper Silurian only two are yet known: *Monograptus Hisingeri* and *Monogr. priodon.*

This assemblage of forms is unknown outside of South Scotland, but if we suppose the Hawick rocks to yield the Upper Silurian forms which are found in association with Gala species at Tieveshilly (Ireland), etc., in beds which appear to come into the place of the

Hawick beds, it becomes at once recognizable in several foreign localities.

A few of its commoner forms are met with in Thuringia, as at Linda, Grafenwarth, etc., but the whole group is especially characteristic of the Colonies of Mons. Barrande, and possibly of the greater part of the band E. e.—1, which he places at the base of his Upper Silurian. In Sweden some of its species occur in the higher beds of Dr. Linnarsson's Upper Graptolitic Schists (zone B. of Table), almost at the summit of his Lower Silurian. In France and Spain a few of the same forms have been detected in beds believed to lie either at the summit of the Lower or at the base of the Upper Silurian of those countries.

Group C.—This is constituted by the *Monograptidæ* occurring in the Riccarton Beds, and in the Lower Division of the Silurians of the Pentland Hills. Its remarkable distinctness, as a whole, from that derived from the Gala Series, owing to the unfossiliferous nature of the intervening Hawick rocks, has already been sufficiently insisted upon. Its peculiar forms in South Scotland are: *Monograptus colonus*, Barr.; var. *dubius*, Suess; *M. Riccartonensis*, Lapw.; *M. Flemingii*, Salter; *M. vomerinus*, Nich.; and *Cyrtograptus Carruthersi*, Lapw.

Its unequivocal Upper Silurian character is clear from the fact that its Graptolites are those of the Coniston Flagstones of the Lake District, and of the strata of the Wenlock and Lower Ludlow formations of Siluria.

On a general review of the whole of the facts adduced in the foregoing pages, it appears that we possess at the present time sufficient evidence to justify us in accepting the following generalizations.

Of the numerous forms of Graptolites belonging to the family of the *Monograptidæ* afforded by the Silurian rocks of the South of Scotland, each has a certain definite restriction in the vertical series of deposits.

Further, the three successive rock-groups of Birkhill, Gala and Riccarton possess each a well-marked assemblage of *Monograptidæ*, which is easily separated as a whole from that of the other formations.

And finally, the general vertical succession of species and varieties of the *Monograptidæ* in these rocks is in complete accordance with that in Ireland, Westmorland, Central Europe, and Scandinavia.

My obligations to Mr. W. A. Sanderson have been already acknowledged. Of others to whom I am specially indebted for assistance in these researches, the chief is my friend Mr. Jas. Wilson of Edinburgh, by whom, or in whose company, the majority of the forms figured were originally collected in the field. Prof. H. A. Nicholson generously accorded me the valuable privilege of studying his magnificent collection of English forms from the Lake District and Siluria. Mr. W. Swanston, of Belfast, submitted for examination all the species discovered by him in the Silurian rocks of County

Down. Mr. Wm. Carruthers, F.R.S., placed at my disposal some Scandinavian forms. Mr. John Hopkinson, F.L.S., etc., forwardel for comparison the forms collected by him in the Lower Ludlow beds of Shropshire; Mrs. W. Gray those of the Middle Silurians of Girvan; and Mr. Jas. Henderson those of the Upper Silurians of the Pentland Hills.

IV.—NOTE ON THE FOSSILS FROM THE GLACIAL DEPOSITS OF THE NORTH-WEST COAST OF THE ISLAND OF LEWIS, OUTER HEBRIDES.

By R. ETHERIDGE, JUN., F.G.S.

IN a paper, read before the Geological Society of Lopdon (June 25, 1873), "On the Glacial Phenomena of the Long Island or Outer Hebrides,"[1] Mr. James Geikie mentioned the occurrence of two descriptions of stony clay in the Long Island. The first of these deposits or "Bottom Till" occupies the low ground of the island, and is derived from the disintegration chiefly of gneissic rocks, and so far as observation went proved to be unfossiliferous. The other deposit was found in the north of Lewis, along the coast, and consists of two beds of unstratified stony clay containing fragments of shells, the lower resting on rock *in situ*. The beds in question also contain numerous blunted stones and boulders, and are separated by intermediate stratified beds containing shells and other fossils, usually in a better state of preservation than those in either of the stony clays. In his "Great Ice Age," Mr. Geikie describes[2] these deposits more at length, and gives the following general succession of the Glacial deposits in Lewis, in descending order:—

1. Boulder-clay.
2. Sand, gravel. and coarse shingle, with rolled and angular fragments of shells.
3. Dark bluish-brown clay and silt, with shells, many of them mere fragments.
4. Boulder-clay, with broken shells.
5. Till.

In 1874 Mr. Geikie paid another visit to Lewis, with the view of further carrying out his observations on the glaciation of the island, and during that visit I had the pleasure of accompanying him. The following list gives the fossils obtained by us from the two localities at which the fossiliferous beds had been noticed. It was our intention on starting to have devoted much more time to this branch of the subject, but circumstances over which we had no control prevented this, and we had to content ourselves with one short visit to each of the localities. Could more time have been devoted to the search, I feel sure the list would be considerably augmented, especially in the more minute organisms. Unfortunately we had no appliances for bringing away with us portions of the sands and clays for washing and sorting, all the smaller organisms having been obtained by washing the matrix contained within the mollusca.

The forthcoming new edition of Mr. Geikie's work renders it unnecessary to say more on the geology of the subject, as that will be fully treated of there.

As before stated, two localities were hurriedly searched, viz.

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[1] Quart. Journ. Geol. Soc. vol. xxix. p. 532.

[2] pp. 209–11.

Traigh Chrois and Traigh Shuainoboist. They are both situated on the north-west coast of Lewis, a little to the south-west of the Butt. The former is nearly 1¼ miles west of the village of Swainabost, and the latter about 1 mile north-west of the same. We likewise observed a similar set of fossiliferous beds on the coast to the south-east of Port of Ness, but time did not permit us to make any collection.

In the succeeding list I have indicated the two localities by the initials T.C. and T.S. respectively, the former for Traigh Chrois, the latter for Traigh Shuainoboist. Those species which have been met with in the Boulder-clay of Caithness are indicated by an asterisk placed before them.

LIST OF FOSSILS FROM THE GLACIAL DEPOSITS OF THE NORTH-WEST COAST OF LEWIS.

UPPER BOULDER-CLAY.

Balanus balanoides, Linn.		T.S.
**Cyprina Islandica*, Linn.		T.S.
**Saxicava Norvegica*, Spengler		T.S.
**Turritella terebra*, Linn.		T.S.

LAMINATED BEDS.

**Triloculina oblonga*, Montg.		T.S.
**Quinqueloculina seminulum*, Linn.		T.S.
**Dentalina communis*, D'Orb. var.		T.S.
**Truncatulina lobatula*, Walker	T.C.	T.S.
**Polystomella crispa*, Linn.		T.S.
**Nonionina asterizans*, F. & M.	T.C.	T.S.
* „ *depressula*, W. & J.	T.C.	T.S.
Balanus balanoides, Linn.		T.S.
**Salicornaria*, sp.		T.S.
**Pecten Islandicus*, Müller		T.S.
Leda pernula, Müller	T.C.	
**Cardium echinatum*, Linn.	T.C.	T.S.
* „ *edule*, Linn.		T.S.
**Cyprina Islandica*, Linn.	T.C.	T.S.
**Astarte sulcata*, Da Costa	T.C.	T.S.
„ *compressa*, var. *striata*, Müller	T.C.	T.S.
„ *depressa*, Brown	T.C.	
**Tellina balthica*, Linn.	T.C.	T.S.
Mactra solida, Linn.		T.S.
**Mya truncata*, Linn.		T.S.
**Dentalium entale*, Linn.	T.C.	T.S.
**Turritella terebra*, Linn.	T.C.	T.S.
**Natica Alderi*, Forbes		T.S.
„ *Montacuti*, Forbes		T.S.
**Aporrhaïs pes-pelicani*, Linn.		T.S.
**Buccinum undatum*, Linn		T.S.
**Trophon truncatus*, Ström		T.S.
Fusus gracilis, Da Costa		T.S.

LOWER BOULDER-CLAY.

Truncatulina refulgens, Montf.		T.S.
**Polystomella striatopunctata*, F. & M. ?		T.S.
**Cyprina Islandica*, Linn.	T.C.	T.S.
**Astarte sulcata*, var. *elliptica*, Brown		T.S.
„ *compressa*, var. *striata*, Müller		T.S.
**Saxicava rugosa*, Linn.	T.C.	

The foregoing list will show that the largest proportion of our fossils were obtained from the intercalated laminated beds, although we found both the Upper and Lower stony clay to be fossiliferous.

Here and there in the Upper Clay are to be seen sandy nests or patches; these are also fossiliferous, and from one of them I obtained tolerably good specimens of *Turritella terebra*, and pieces of *Cyprina Islandica*.

Mr. Geikie has already pointed out the resemblance of the Lewisian fossiliferous Boulder-clays to that of Caithness,[1] and it now only remains for me to add that of the twenty-two forms above mentioned taken from the beds collectively sixteen are met with in the Caithness Boulder-clay, one (*Leda pernula*) is represented by a variety. Another, here a variety (*Astarte compressa*, var. *striata*), is there represented by the typical form, whilst four (*Mactra solida*, *Fusus gracilis*, *Astarte depressa*, and *Natica Montacuti*) are not given in Mr. C. W. Peach's list of Caithness fossils. Of the Foraminifera one only (*Truncatulina refulgens*) is not mentioned by him.[2]

So far as I am aware, the Caithness deposit is the only one in Scotland which has yielded *Salicornaria*, as I do not, at the present moment, recollect any mention of its occurrence in the Clyde Valley beds. Two fragments have turned up in the Lewis washings. On looking over the foregoing list one or two interesting points may be dwelt on. *Dentalium entalis* and *Turritella terebra* are of frequent occurrence in the Lewis beds, although not generally abundant in other Scotch Glacial deposits. The former of the two species appears to be chiefly confined to the beds met with in the north of Scotland, as Wick, Belhelvie, King Edward, and Gamrie;[3] the latter is to be found in Caithness, and at Gourock, and Auchleuchries.[4] Again, *Natica Montacuti*, of which we obtained only one specimen, is said to occur in Bute, in the Clyde beds;[5] whilst *Fusus gracilis* has, so far as I am aware, only been recorded from the Dalmuir deposit, by Messrs. Crosskey and Robertson,[6] and in this case only the fry. The single specimen (1 valve) of *Astarte depressa*, Brown, was determined for me by Dr. Gwyn Jeffreys, and is a peculiarly Arctic form. Dr. Jeffreys appears to consider it identical with *Astarte crebricostata*, Forbes,[7] and under that name we have it recorded from Bute and Dalmuir by the late Mr. James Smith.[8] This, with *Pecten Islandicus*, are the only two really Arctic shells in the list, although there are several northern forms, as *Leda pernula*, *Cyprina Islandica*, *Saxicava Norvegica*, *Natica Montacuti*, *Fusus gracilis*, etc. Such Arctic forms as *Rhynchonella psittacea*, Linn., *Astarte borealis*, Chem., *Glycimeris siliqua*, Lamk., and *Dentalium abyssorum*, Sars., which have been found by Mr. C. W. Peach in the Caithness Boulder-clay, have yet to be met with in the Lewisian deposits.

[*Note by Mr. Geikie.*—" My chief object in revisiting the north part of Lewis was to re-examine the distribution and extent of the shelly

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[1] Great Ice Age, p. 211.

[2] See C. W. Peach, Proc. Edin. Physical Soc. vol. iii. pp. 38 and 396. Brit. Assoc. Rep. for 1862, Trans. of Sections, p. 84; 1864, p. 62; and 1866, p. 65.

[3] Jamieson, Quart. Journ. Geol. Soc. vol. xxi. p. 198.

[4] Prof. A. Geikie, Glacial Drift of Scot. p. 182. Jamieson, l.c. p. 199.

[5] Smith, Researches, p. 52.

[6] Trans. Geol. Soc. Glasgow, vol. ii. p. 281.

[7] British Conchology, vol ii. p. 320.

[8] Researches, p. 47; and Crosskey and Robertson, l.c. p. 274.

Boulder-clays near the Butt, with the view of determining, if possible, the succession of physical changes that ensued after the deposition of the unfossiliferous bottom till which covers so wide an area in the Long Island. I have given elsewhere ("Great Ice Age," 2nd edit. chap. xvi.) a detailed account of the evidence, and only state here in a few words the genera conclusions arrived at. They are these: 1. Period of intense glaciation: Lewis overflowed by ice coming from the mainland: formation of unfossiliferous bottom till. 2. Recession of the ice-sheet: ice vacates the Minch, which becomes tenanted by northern mollusca. 3. Return of ice-sheet: ice overflows north part of Lewis: formation of lower shelly till or Boulder-clay. 4. Recession of the ice-sheet: partial submergence of the land: arctic and boreal shells live in the Minch: formation of stratified deposits between the tills. 5. Return of ice-sheet: ice overflows north part of Lewis: formation of upper shelly till or Boulder-clay. 6. Final retreat of ice, followed by partial submergence."]

Before closing these remarks I wish to notice certain peculiar burrows penetrating a piece of shell, apparently that of *Cyprina Islandica* from Triagh Chrois. The markings are of two kinds. The first are fine straight grooves intersecting one another at various angles, the second are formed of a minute perforation or foramen with a fan-shaped series of ramifying tubuli, always on one side of the foramen (Figs. 1 & 2). The specimen was submitted to the Rev. A. M. Norman, who kindly informed me that both kinds of perforations are probably due to fungi. He thinks that the fan-shaped perforations are caused by a fungus in a state of fructification of similar form to *Stysanus caput-medusæ.*[1] Professors Kollicker and Wedl consider that all the tubuli described by Dr. Carpenter in the shells of Bivalves are caused by parasites; the former ascribes them to Unicellular Fungi, the latter to Confervæ.[2] An interesting fact in connexion with these fan-shaped perforations is that Mr. C. W. Peach has in his cabinet several pieces of *Cyprina Islandica,* and other shells, from the Caithness Boulder-clay, covered with them. The above figure, from a drawing by Mr. B. N. Peach, represents the perforations as seen on the Hebridean specimen from the laminated beds at Traigh Chrois. I have in conclusion to express my thanks to Mr. H. B. Brady for determining the Foraminifera, to Dr. Gwyn Jeffreys for checking my determinations of the Mollusca, to the Rev. A. M. Norman for notes on the above figure, and to Mr. J. Bennie for assistance in cleaning andsorting the fossils.

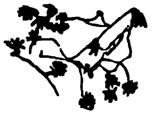

Fig. 1.*

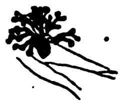

Fig. 2.**

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[1] See Carpenter, The Microscope, 5th ed. 1875, p. 389.

[2] Kollicker, "On the Frequent Occurrence of Vegetable Parasites in the Hard Structures of Animals," Proc. Royal Soc. vol. x. p. 95.

* Series of fan-shaped ramifying tubuli seen in shell of *Cyprina Islandica.*

* * A single fan-shaped mass very highly magnified.

V.—FOSSILIFEROUS PLIOCENE CLAYS OVERLYING BASALT, NEAR THE SHORE OF LOUGH NEAGH.

BY EDWARD T. HARDMAN, F.C.S.; H.M. Geol. Surv., Ireland.

(PLATE XXII.)

IN the Report of the British Association for 1874[1] will be found the abstract of a paper on the Age and Mode of Formation of Lough Neagh, with a description of the Pliocene clays which form an ancient and extensive delta at its southern extremity. At the time I penned the paper in question, although I was perfectly satisfied from cumulative circumstantial evidence that the clays were of much more recent date than the Miocene Basalt which surrounds the lake on three sides, I had no actual proof to bring forward—the junction of the basalt and the clay beds being nowhere visible, so far as I had had an opportunity of examining the district, this comprising all the shores of the Lough, with the exception of a small corner near Crumlin; and it was therefore necessary to state, even at the risk of tediousness, the reasons why the clays must be considered to be the uppermost, and to be of Pliocene age.

During a recent visit to this hitherto unexplored locality, accompanying Professor Hull, for the purpose of tracing the eastern boundaries of these beds, we were so fortunate as to meet with a well-exposed section, showing the clays resting on a denuded surface of basalt. This was a pleasant encounter. At the same time, one could hardly help a slight feeling of regret that so much elaborate argument had been already in a manner "fooled away," as Mark Twain has it—to prove what was here a self-evident fact, had one but seen it in time. We were also so lucky as to find at this place the only fossils which, with the exception of plants, have yet been discovered in the Lough Neagh clays.

It may be well to mention that these beds form a very extensive and important deposit, spreading (under water and on shore) over an area that cannot be less than 180 square miles, and probably in some places about 500 feet thick. They repose on the basalt, and are covered by drift. All the evidence we have points to their being of Pliocene Age.

The locality where the particular beds I propose to describe now are found is on the Crumlin River, about a mile from the eastern shore of the Lough, and about 2½ miles from Crumlin village. The basalt is exposed for some distance along the stream, and following it downwards we came upon the following section:—

	SECTION IN CRUMLIN RIVER.[2]	Ft.	In.
A.	River Gravel and Alluvium	18	0
	Dark Grey Laminated Sandy Clay	2	0
f.	„ „ „ full of *Unio*-like shells ...	1	0
	Dark Grey Clay	1	0
m.	Coarse Gravelly Clay—pebbles of quartz and basalt—resting in pockets and erosions of basalt	3	0
B.	Nodular Zeolitic Basalt, greatly eroded	3	0
		28	0

This section is exposed for about 40 yards. The clays are visible for some distance lower down, and in one place exhibit very well

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[1] Trans. of Sections, p. 79.

[2] See Pl. XXII. Fig. 1.

Fig. 1.

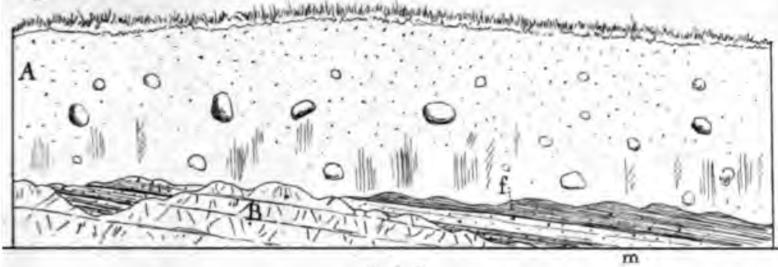


Fig. 2.

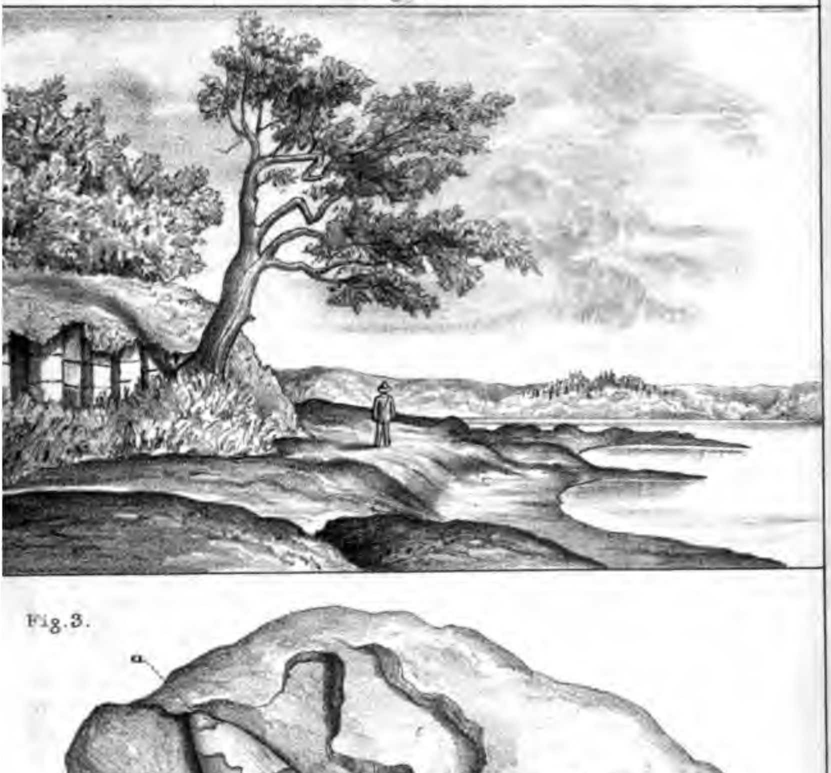
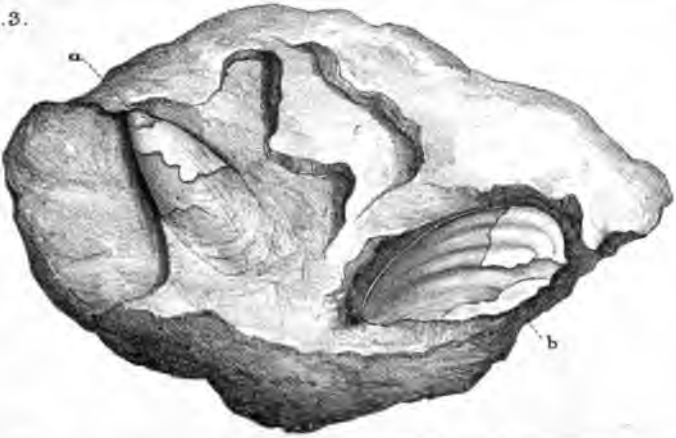


Fig. 3.



Hardman del.

Fossiliferous Clays resting on Basalt Lough Neagh.

marked cleavage. The basalt on which they repose was evidently the ancient shore of the lake. It is greatly water-worn, and the pebbly clays lying on it and in the hollows are clearly shore-beds. A little higher up the stream the basalt rises abruptly into what must have been a bold shore cliff. A deposit of drift disguises the surface appearance of this, but in section it is very distinct. Some distance south of this, on the Glenavy River, the basalt presents an exactly similar aspect. The old cliff is very well shown, while a little lower down the Pliocene clays, full of plants and lignite, are found; but the junction is hidden.

The presence of these ancient cliffs not only serves to mark the former extent of the lake—which must have been at least double its present dimensions—but also shows that glaciation could not have acted very energetically in that district, since in that event it would have undoubtedly removed all traces of them.

A similar shore and cliff may be seen on the northern margin of Lough Neagh, just under Shane's Castle, Antrim (Pl. XXII. Fig. 2). But the clays do not extend so far north as this, and the basalt is laid bare on the shore, presenting rather a remarkable appearance in some places, and rounded as if by ice. Another old cliff occurs along the south side of the point jutting out by Langford Lodge. Both of these are, however, more recent than the drift.

The Lough Neagh Clays had hitherto proved barren of any fauna. I had examined carefully every excavation that had been made in the potter's clay on the south side, without success; nothing but plants being obtainable. The Rev. Dr. O'Meara, whose valuable researches on Irish Diatomaceæ are so well known, thought it likely that these clays might yield Diatoms, and I procured some specimens for him at Professor Hull's request. These, I understand, gave no result; and it appeared certain, therefore, that no fossils, save land-plants, were to be expected from these strata. It was, then, with much satisfaction, that while examining the section detailed above, I came on a bed of clay full of shells.

The fossils are mostly confined to a band about a foot thick, and are very abundant. They appear all to belong to a species of *Unio*. Owing, however, to their extremely delicate structure, and the soft and friable nature of the deposit in which they lie, it was very difficult to obtain good specimens, and unfortunately those which I brought away with me received such damage during their transit that it was almost useless to attempt to determine them. Mr. W. H. Baily, F.G.S., to whom I submitted them, is inclined to think that they may possibly belong to a new species. They are not unlike the *Unio Solandri* (?) of the Upper Eocene of Hordwell Cliff, Hampshire, so far as external appearance goes. In Pl. XXII. Fig. 3 there is a representation of two of the shells, the originals are greatly crushed and dilapidated.[1] (*a*) will perhaps serve to give some idea as to the general character of them—in this one the greater part of the shell is preserved; (*b*) shows only a cast—nearly all the shell having chipped away. The drawing is full size.

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[1] Having been favoured by Mr. Hardman with an opportunity to examine the specimens in question, we have been led to the opinion that the lines of striæ indicate rather a *Mytilus* or *Modiola*-like shell, than a *Unio*; but the shells are too fragmentary to enable one to speak with certainty even as to the genus.—Edit. Geol. Mag.

The shells are extremely thin and fragile, but the structure and markings are perfectly preserved and the nacreous lustre is still quite brilliant. I have no doubt but a palæontologist visiting the locality, and having leisure to make a careful examination, would find many perfect specimens capable of determination, and probably other species as well. In the mean time it is right to place the matter on record—seeing that this place is, so far as I know of, the only locality in the British Isles yielding lacustrine fauna of Pliocene date.

NOTICES OF MEMOIRS.

I.—On Certain Pre-Carboniferous and Metamorphosed Trap-Dykes and the Associated Rocks of North Mayo, Ireland.[1]

By William A. Traill, M.A.I., F.R.G.S.I.; H.M. Geol. Surv., Ireland.

THE author first described the locality as situated in the N.W. of the Co. Mayo, between Downpatrick Head and Broad Haven; and referred to the geological map of Sir Richard Griffith. The physical features of the district presented precipitous coast sections, attaining elevations of 352 ft. at Keady Point; 640 ft. at Benwee Geevraun; and 829 ft. at Benwee Head, and would compare favourably for grandeur and boldness of scenery with many better known localities. The geological formations composing the district belong to the Carboniferous and Metamorphic rocks. The older or Metamorphic rocks lie to the westward, extending from Broad Haven to the Glenglassera river, and consist of flaggy quartzites and micaceous schists, with partings of mica-schist; the mica is often largely crystallized out in hexagonal plates in nests or veins. Foliation is seldom developed, but the original bedding is still clearly retained, with a primary dip E.N.E. at variable angles. They are often much crumpled, contorted, and overlapped, more particularly in the western portions.

The newer or Carboniferous rocks lie to the eastward, and include the Carboniferous Limestones to the S.E. of the district, and the Lower Carboniferous Sandstones and Shales, the bottom beds of which are brought to the surface near the Glenglassera river. These latter comprise white, yellow, and red sandstones, with partings of red and green shales. They dip E.N.E. at from 3° to 8°.

They rest unconformably on the Metamorphic rocks. At Fobernadeevaun, at the mouth of the Glenglassera river, this most remarkable example of unconformability is best seen; it occurs at one side of a fault along which the sea has worn a narrow but deep chasm; the flatter Carboniferous beds dipping at 5° rest on the more highly inclined Metamorphic rocks dipping at 25° to 30°.

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[1] Read before the British Association for the Advancement of Science, Section C. Geology, Glasgow, September, 1876.

The lowest or basal bed of the Carboniferous series is a conglomerate of from one to four feet in thickness, composed chiefly of fragmental vein quartz and pieces of the Metamorphic rocks; it merges imperceptibly into the overlying sandstone beds, and there is no break of continuity. In the geological map referred to, there was represented a band of Devonian rocks intermediate between the others, which he (the author) in all due deference called in question, and which he believed did not exist, the thin conglomerate bed undoubtedly belonging to the Carboniferous series.

The intrusive igneous masses which so abundantly penetrated the rocks of the district, as Trap-dykes, occur in both the Metamorphic and Carboniferous areas, but more abundantly within the former, and belong to very different ages; the one set being Pre-Carboniferous, and the other Post-Carboniferous, and possibly of Tertiary (Miocene) age.

Both classes of dyke may be considered as primarily belonging to the basaltic type, but the one seems in part at least to have been considerably altered by subsequent metamorphic actions. Both sets penetrate the older or Metamorphic rocks, but only the second set the Carboniferous beds.

Though in many respects closely resembling each other, there are certain characteristic distinctions peculiar to each, specially the peculiar weathering of the older dykes, which on the exposed surfaces showed a crystalline white mottling of the weathered felspar crystals through the dark green base.

The junction of the Carboniferous with the Metamorphic rocks being mostly obscured, the direct evidence of the older dykes ending off at that junction was not obtainable, and not finding any *in situ* in the Carboniferous area was only negative evidence; but after long search, undoubted fragments of those characteristic older dykes were found in the conglomerate or basal bed of the Carboniferous rocks, thus proving unquestionably the Pre-Carboniferous age of those dykes.

The older dykes occur mostly in large sheets from 10 to 150 feet in thickness, and are approximately interbedded among the Metamorphic strata, and often contorted with them, though often themselves the cause of the minor crumplings; occasionally they are folded back on themselves, forming large *S* curves.

Instances of these were described and specimens exhibited, from Benmore, and from Belderg Harbour, where the exposed part seems to be the top surface of the sheet, consisting of large humps and bosses protruding through the quartzites and schistose beds. In this typical example, the effects of the metamorphic action at different depths was well shown, the central part being a hard, heavy, and splintery dark steel-blue, micro-crystalline basalt, passing into a fibrous hornblendic schistose rock, with soft green chlorite and nests of green hexagonal chloritic mica, and towards the exterior becoming very schistose, platy, and micaceous, resembling a black or bronze mica-schist; in part these might be considered as Diabases. The felspar seems to be plagioclastic or triclinic, and on the weathered parts shows as characteristic white crystalline mottlings through the finely crystalline greenish base.

Adventitious minerals are developed in this and other similar dykes, in nests and aggregations, such as mica, chlorite, epidote, garnets, hornblende, quartz, calcite, and varieties of felspar and iron pyrites.

At Laghtmurragha and Glencalry other dykes were described, belonging to this class. Among these the hexagonal and spheroidal structures are never developed, and they are scarcely ever found to be vesicular or amygdaloidal.

The second series or Post-Carboniferous dykes are probably of Tertiary age, and seldom here attain a thickness of over 25 feet, and generally run in straight and definite directions W.N.W. and E.S.E., apparently filling vertical cracks or fissures, or along lines of faults. When occurring together, they always cut the sheet-like dykes of the older series; they are basalts with local variations, and are frequently hexagonal or spheroidal in structure, often amygdaloidal and decomposing, thereby leaving the original fissures open or enlarged into narrow chasms penetrating the cliffs. One of these separates Illanmaster from the mainland, another forms a chasm between vertical walls 450 feet deep, and in part scarcely 10 feet wide, and separates four small islands from their respective headlands, the view looking down this cleft, with its four pairs of opposing perpendicular cliffs on either side being almost unique.

II.—Geologists' Association—Inaugural Address by the President.

Evolution of Plant Life.

On November 3rd, Mr. W. Carruthers, F.R.S. (the Keeper of the Botanical Department of the British Museum), gave the Presidential Address to the Geologists' Association, in the Library of University College, his subject being a comparison of the history of plant life preserved in the rocks so far as we know it, and its relation to the theory of evolution.

The origin of the existing organic forms has always been a question of interest. Until a comparatively recent period little diversity of opinion prevailed in regard to this matter amongst students of science in Europe. The position stated by Moses in the opening sentences of the Old Testament, in which all matter, organic and inorganic alike, is traced to the operation of an external and supernatural Creator, was universally adopted, though it was often misunderstood and misinterpreted by its expounders.

In the beginning of this century Lamarck proposed his Evolution theory, according to which all organisms are derived from some few simple original forms, which had come into existence by spontaneous generation out of inorganic nature. Although Lamarck's theory found a few supporters, it was comparatively neglected by men of science until Darwin, in 1859, published his "Origin of Species by Means of Natural Selection," which, at least in this country, has wrought an almost complete change in opinion as to the origin of our present life forms. His theory of development as applied to the Vegetable Kingdom may be thus briefly stated:—The characters of plants are transmitted to their descendants. New characters besides those inherited may arise in some descendants which were not possessed by the parent. When these new characters are transmitted, and are permanent, the plants possessing them become a variety. Some plants have a special tendency to variation; others are remarkably constant in their characters. No explanation has been given of the reason for these differences in the nature of plants or of the cause of the appearance of new characters. The differences are at first small. Their continuance depends on external causes. In course of time new characters appear, or the old become intensified, and in the struggle for existence the varieties only which possess the characters best fitted to resist the prejudicial influences that surround them are able to maintain their ground. The less fortunate varieties perish, and in this way the connecting links between the common descendants of the original stock are destroyed. These descendants becoming more pronounced in their characters are recognized as species. The only difference between a variety and a species is the amount of divergence and the constancy of the characters. Further, this in a greater degree is the only difference between a species and a genus. It is accordingly concluded that all the forms now observed in the vegetable kingdom are due to the continual accumulation of differences in the genetic evolution of these plants from the one or the few simple original forms. It is held that the natural system of plants is the external expression of this phylogenesis, or genetic relationship, that the development of a plant from the embryonal cell to the perfect individual is a short and quick repetition of the genetic development of the tribe to which it belongs, and that the rocks of the earth reveal, so far as the record of life is preserved, the various steps by which the phylogenesis actually was accomplished.

Mr. Carruthers proceeded to draw attention to this last aspect of the subject, as that which specially affects geologists. It deserves careful investigation, for if the theory of evolution be true, then the fossils which have come to our knowledge represent as far as they go the extinct progenitors of existing plants, and on this account possess a higher interest to us than their comparative anatomy or systematic position can give to them. Reference was made to the imperfection of the geological record, but it was urged that it was right to compare our knowledge of it as far as it goes with the theory. What, then, is the phylogeny of the Vegetable Kingdom? The most rudimentary plants are either Fungi or Algæ. The elementary fungal forms are believed by some to be the original stock of the vegetable kingdom, while others hold the primitive forms were Algæ. Mr. Carruthers argues against Fungi being the earliest, on the ground chiefly that they fed on organized substances, and stated that evolutionists must look for the earliest plants among the Algæ. What is the testimony of the rocks as to the plants existing during the long early periods of the earth's history? Mr. Carruthers showed that the vegetable markings preserved in the earliest rocks are, though indistinct, referred to sixteen species of Algæ. But the nature of the plants which could flourish in the conditions under which these deep-sea deposits were found, and the changes that have taken place in the primal strata since their deposition, prevent us expecting any extensive representation of these early floras. So far as the plant remains go, they meet the requirements of the evolutionist who looks upon the Algæ as the primeval plants.

In the phylogenesis of the Vegetable Kingdom we next come to the evolution of Fungi, Lichens, Mosses, and Hepaticæ, all of which are cellular plants. They came into existence, it is supposed, with the Devonian period—the beginning of the newer Palæozoic series. As, however, no trace of any of these groups, except the mycelium of one or two species of fungi, has been detected in any of the Palæozoic rocks, they supply no evidence for or against the hypothetical account of their evolution.

The later Palæozoic rocks abound in plant remains. The first evidence of land plants on the globe is met with, as far as our knowledge at present goes, in the Devonian rocks. Here the three principal groups of vascular cryptogams appear together in highly differentiated forms. All of them—Ferns, *Equisetaceæ* and *Lycopodiaceæ*—possess the same essential structure as their living representatives, and in all the subordinate points in which they differ they possess characters indicative of higher organization, whether in the vegetative or reproductive organs, than are found in existing forms. The three orders appear together in these later Palæozoic rocks, and that not in simpler or more generalized types, but with more varied and more complex structures than are found in their living representatives. Thus, among Ferns there is lost a remarkable group with a fundamentally different stem structure, which was contemporaneous in the Palæozoic ages with the type of Ferns that have been represented all through the epochs, and are now abundant on the globe. The *Equisetaceæ* were represented by a larger number of generic groups than are found in our present Flora. Their stems were arborescent, the leaves large, and their fruit cones protected by special scales, but the spores were similar in size and form to those in the humbler living species, and were even furnished with hygrometric elaters. The *Lycopodiaceæ* were also huge trees, and represented by several generic groups. The stem structure, while fundamentally agreeing, like those of the arborescent *Equisetaceæ*, with the structure of the stems of their living representatives, was more complex, being suited to their arborescent habits.

But the Flora of these later Palæozoic rocks include higher elements even than vascular cryptogams, for in the Devonian series we have coniferous plants, increasing greatly in number and variety in the Carboniferous period; and in the Calciferous Sandstones at the very base of the Carboniferous measures, there has been found an undoubted angiospermous plant. The step from the spore-producing cryptogam to the seed-bearing phanerogam is a very great one. No doubt there is a general external resemblance between a lycopod and a conifer, and many points of analogy between the development of the seed and the various stages through which a lycopod passes from the germination of the spore to the growth of the fertilized archegonium. But like is here, as it is often elsewhere, an ill mark, for the resemblance is purely superficial. The minute tissues of the conifer, as well as the method in which they are arranged, differ entirely from anything either in the existing or extinct lycopods, while the production of a seed, even though it be without a protecting ovary or fruit, at once distinguishes the gymnosperm from the spore-bearing cryptogam. According to Haeckel, the gymnosperm sprang out of the *Lycopodiaceæ* during the Carboniferous, or possibly in the Devonian period. But undoubted coniferous wood was discovered by Hugh Miller in the Lower Devonian rocks of Cromarty, and several anomalous woods have been described by Unger from the Thuringian rocks of the Devonian age which are referred by him to *Coniferæ* without any positive evidence except the absence from them of ductiferous tissue. Had these woods been of earlier age than Miller's Cromarty wood, they might have been looked upon as one of the steps leading up to the true coniferous structure, but they occur in beds of Upper Devonian age. The Calciferous Sandstones at the base of the Carboniferous period contain numerous and fine specimens of coniferous wood. Some trees at this time had attained to an immense size. The first appearance of the gymnosperms is not in the form of a generalized type, but both the wood and the fruits present a remarkable variety of genera and species as highly differentiated as the existing forms. In connexion with this remarkable development of *Taxineæ* in the Palæozoic rocks, it deserves to be noticed that this section of the *Coniferæ* are all diœcious, while in the other groups the flowers are generally monœcious.

The history of monocotyledonous plants, as far as it is preserved in the rocks of the earth, is very curious. We have to take it up here, for the first true monocotyledon is the stem and spike of an aroideous plant, of which one well-preserved specimen was discovered nearly forty years ago by Dr. Paterson in the Calciferous Sandstones near Edinburgh. Additional specimens of this or an allied species have been recently described by Mr. Etheridge, jun., from the same beds. Four species of monocotyledons have been found in the Trias, seven in the Lias, the same number in the Oolite, 15 in the Chalk, 97 in the Eocene. 185 in the Miocene, and two in the Pliocene. We find, then, that the three groups of vascular cryptogams, and the seed-bearing gymnosperms, appear together in the Devonian rocks, and that monocotyledons appear in the lowest beds of the immediately succeeding Carboniferous system. Further, that these earliest plants are not generalized forms of the various tribes to which they belong, but that they are as highly specialized as any subsequent representatives of the particular tribe, and that wherever they differ from later plants, it is in the possession of a more perfect organization. It would be contrary to the theory of evolution to suppose that the highly-organized cryptogams, the gymnosperms, and the monocotyledons, were each developed at one step from the cellular plants which formed the only vegetation of the pre-Devonian periods. No doubt there is in the older Palæozoic rocks a great absence of any records of land life. But the evolution of the vascular cryptogams and the phanerogams from the green seaweeds, through the liverworts and mosses, if it took place, must have been carried on through a long succession of ages and by an innumerable series of gradually advancing steps; and yet we find not a single trace either of early water forms or later and necessarily still more numerous dry land forms which should represent these intermediate forms. This cannot be due to the physical conditions connected with the preservation of organic remains, for the conditions that permitted the preservation of the Fucoid in the Llandovery rocks at Malvern, and of similar cellular organisms elsewhere, were at least favourable to the preservation of such plants as these must have been if they ever existed.

Mr. Carruthers then entered on the consideration of the higher or dicotyledonous division of flowering plants. Their testimony for or against the theory of evolution is the more important, because—first, of their higher organization, by which, as regards their vegetative organs, they are sharply separated from the monocotyledons, and as regards both vegetative and reproductive organs from the gymnosperms; secondly, from the existence of numerous differences which supply generally obvious and well-defined characters for their systematic classification, and which would consequently assist in following the steps of their evolution; and thirdly, from their appearance in strata of comparatively recent age, and which are consequently much better known than the Palæozoic deposits. Dicotyledons are usually divided into three groups—*Apetalæ*, *Monopetalæ*, and *Polypetalæ*.

After a *résumé* of Haeckel's scheme of the phylogeny of these groups, Mr. Carruthers proceeded: Now let us see what is the record preserved to us in the rocks. Dicotyledonous plants make their appearance in strata which are referred to the Upper Cretaceous series. No trace of these plants has yet been detected in any earlier stratum. There is no palæontological foundation for the suggestion that the *Apetalæ* existed in the Trias and Jura periods. It is difficult to realize that the absence of dicotyledons can be due to any cause but their absence from the then existing vegetation. The conditions favourable to the preservation of Ferns, gymnosperms and monocotyledons, in the Secondary rocks, must have been favourable also to the preservation of dicotyledonous plants. Not only are dicotyledons entirely absent, but there has not been discovered a single specimen of a gymnosperm or monocotyledon which exhibits in any point of its structure a modification towards the more highly-organized dicotyledon. Further, when the dicotyledons appear in the Upper Cretaceous beds, representatives of the three great divisions are found together in the same deposit. Moreover, these divisions are not represented by generalized types, but by differentiated forms which, during the intervening epochs, have not developed even into higher generic groups. Thus, amongst the Apetalæ the *Myricaceæ* are represented in the Cretaceous rocks by two congeners of our bogmyrtle; the *Cupuliferæ* by six species of oak and one of beech; the *Salicaceæ* by six species of willow and nine of poplar; the *Moreæ* by six species of fig; and the *Laurineæ* by a laurel and six species of sassafras. Then following Haeckel's order of evolution, among the *Polypetalæ* the *Araliaceæ* are represented by a species of *Aralia*; the *Anacardiaceæ* by a species of *Rhus*; the *Sapindaceæ* by a maple, and the *Magnoliaceæ* by five species of *Magnolia* and two of the tulip-tree. And among the *Monopetalæ* the *Asclepiadaceæ* are represented by a species of *Nerium*, the *Ebenaceæ* by a *Diospyros*, and the *Ericaceæ* by an *Andromeda*.

While the rocks give no evidence of any plant leading up to these various orders of dicotyledons, it is, as it appears to me, equally important to notice, in its bearing on the theory of mechanical evolution, that the generic groups I have just named have persisted from the first appearance of dicotyledons throughout the whole of the intervening ages, and still hold their places among the existing forms of vegetation. The persistence of generic and specific types is very significant in its bearing on this theory, and our certain knowledge of the life of many existing species of phanerogams and cryptogams which have come down from the glacial beds has not been sufficiently considered. Let us take a case: None can be better suited for the purpose than the small willow, *Salix polaris*, detected in the lowest pre-glacial beds at Cromer and in deposits of the same age at Bovey Tracey. This plant still lives in the Arctic regions of both the Old World and the New. The genus *Salix* is a singularly variable one, and should supply satisfactory data for an evolutionist who is working out his theory. Mr. Carruthers proceeded to speak of the 160 species, 222 varieties, and 70 hybrids known of the genus *Salix*. It is easy to construct a phylogenetic tree of the genus. The small branch which represents the species *S. polaris* represents in time the period between the pre-glacial beds and our own. The six allied species lead up to the group branch, the four groups to the sub-genus, and the seventeen sub-genera to the genus. But having reached the branch representing the generic form, we have made but little progress in the phylogenesis of *Salix*. We have to lead up the allied genera to the generalized ordinal form, and these ordinal forms to a generalized and simple parent apetalous plant. Still further we must go by some utterly unknown and to me inconceivable series of types backwards to the monocotyledon and gymnosperm, and from them back to the primal and spontaneously developed *Monera*. The time required for such evolution is, Mr. Carruthers says, beyond conception, and vastly greater than even the largest estimate of geologic time that has ever been made. That the rocks testify to a development of some kind is beyond doubt, but development is not necessarily the sole property of the mechanical evolutionist. At present we have no data to guide to a solution of the question as to the *mode* by which the development was accomplished. One thing is certain, that the whole testimony of the Vegetable Kingdom, as it is known to us from the remains preserved in the stratified rocks, is opposed to the doctrine that the development is due to *evolution by descent*.

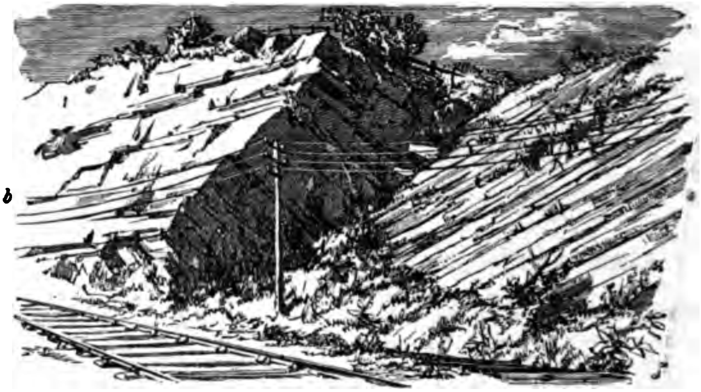
while we should strongly recommend the work of Mr. Woodward, if it were only for its clear arrangement and lucid style, we are especially glad to welcome it as containing an amended classification of the sedimentary rocks.

The plan followed by the author approaches that adopted by Phillips, or rather Conybeare and Phillips, who gave great prominence to the geographical side of the question, and wrote an account of the British Isles under their geological divisions, rather than a description of the different formations, leaving you to find by reference to maps and other sources where the best examples of the rocks might be seen.

The first important change introduced by Mr. Woodward is the acknowledgment of the correctness of the classification of Professor Sedgwick in the Cambrian and Silurian rocks.

The principles of classification which Mr. Woodward has stated so clearly in his introduction would not allow him to do otherwise than adopt the natural grouping first so clearly made out by Sedgwick, and followed by Sterry Hunt in America, Gaudry in France, Dewalque in Belgium, and an ever-increasing number elsewhere.

As we turn over the pages we find under each principal group a short description of the more important sub-divisions. But sometimes, as *e.g.* under Inferior Oolite, a fuller and more frequent repetition of tables is wanted, to enable the student to see whether under the various headings are described strata synchronous and homotaxial, or only small local and subordinate beds.



Cutting near Uphill (Bristol and Exeter Railway). (p. 423.)

a. Lower Lias, faulted against *b*. Carboniferous Limestone.

In some cases, as evidence comes in, we shall expect in later editions clearer definitions of boundary, as *e.g.* between the Silurian and the variable deposits which mark the next great continuous submergence of which we have clear traces in the British Isles.

A similar difficulty meets us in defining the earliest accumulations of the period of submergence, during a later part of which the Jurassic strata were deposited.

Mr. Woodward, unwisely, we think, adopting the Greek name Poikilitic for the older English New-Red, has, however, done what is most important, and taken the Permian (or what remains of it when the stained Carboniferous has been left out) into the Mesozoic Group. It would have been well had he given a section of the so-called Permian, resting as it does in many places in the North-West of England unconformably on the denuded edges of the lowest Carboniferous rocks.

The judicious remarks at the commencement of the chapter on the Cretaceous strata show that he has clearly appreciated the difference between a great break, representing a long interval of time, and a series of small interruptions in the local continuity of conditions which do not give such obvious and well-marked boundary-lines, and where we may wait for more detailed and extended work.

In the Tertiary rocks Mr. Woodward accepts the strong stratigraphical evidence that the Hempstead beds are more closely connected with the Eocene than with the Miocene.

In the concluding chapters he has described other geological phenomena depending upon denudation, metamorphism, etc., and has added much useful information in an appendix.

The small errors which have crept in, chiefly in the latter part of the work, will probably be pointed out by friends, and corrected in subsequent editions, which we anticipate will surely be called for, as the work supplies a want felt both by teachers and students.

It forms a useful handbook for those who are working at special points, and they can increase its value by putting in for themselves exact references to the many authors quoted throughout. To the student we can confidently recommend the book for its clearness and accuracy. T. M'K. Hughes.

Trinity College, Cambridge.

⁂ The illustrations, drawn by Mr. Edward Fielding for this work, are extremely good. We give three, taken at random, which, as specimens of wood engraving, deserve high commendation; others in the book are even superior in geological effect.

REPORTS AND PROCEEDINGS.

Geological Society of London.—November 8, 1876.—Prof. P. Martin Duncan, M.B., F.R.S., President, in the Chair.

A Portrait of the late G. Poulett Scrope, Esq., F.R.S., F.G.S., was presented by Prof. J. W. Judd, F.G.S.

The following communications were read:—

1. "A short notice of a new exposure of Rhætics near Nottingham, in a letter from E. Wilson, Esq., F.G.S., dated November 3rd, 1876," in which he said:—

Since March, 1875, when I drew public attention to the occurrence of Rhætics near Stanton, on the new Midland line from Nottingham to Melton (notice whereof has been already communicated to the Geological Society), that section has not been any further exposed. Meanwhile the London and North-Western Railway Company are rendering geological science a service by showing a similar but more complete succession of Rhætics in a cutting close to Barnston, on their new Bingham branch. Here the uppermost Keuper marls, with their gypsum bands, are succeeded as usual by the hard light blue marls (? lower Rhætic), 12 feet exposed. Above these come the '*Avicula-contorta*' shales, consisting below of about 13 feet of 'paper shales,' with their variable yellow sandstones in their upper portion, and a 2-inch bone-bed replete with the usual fish remains, etc., 1 ft. 6 in. from their base, and graduating up into a series of more earthy and thickly laminated dark blue shales, estimated thickness 18 to 19 feet. Odd limestone nodules occur about the middle of their last series, and at from 2 to 3 feet from the top similar nodules set in, becoming rather more plentiful upwards, and in the highest 6 inches, forming an incomplete layer. These Rhætics are capped by alternating thin-bedded blue limestones and brown clays (Lower Lias), 10 feet exposed; the lowest limestone of which, at the base a thin-bedded, compact, or concretionary bed from 3 to 7 inches thick, contains *Modiola minima* and *Myacites unionides.* These beds appear to be the equivalents of the 'Firestones' and 'Guineas' of Warwickshire, and of similar beds lately noticed by Mr. Harrison near Leicester, and to indicate the absence of the 'White Lias' at this point. The dip of all the above beds is the same, viz. 2° to 3° a little north of S.E. (the direction of the line), and there is no evidence of unconformity. The succession is apparently the same at Barnston as on the Nottingham and Grantham line at Elton, 3½ miles north-east, between which places and beyond to Orston the *Avicula-contorta* shales form a low but very clearly defined escarpment along their outcrop.

2. "Note on the Red Crag." By W. Whitaker, Esq., B.A., F.G.S.

The object of this paper is to show that what had been taken to be an irregular line of erosion between a certain unfossiliferous sand and the shelly Red Crag (in Suffolk) was really a line of dissolution of shells, the sand being simply Red Crag deprived of its fossils through percolation of water. This is shown to be the case from the facts that in some places lines of bedding and false-bedding extend from the Crag into the sand, and that impressions of Crag-shells are found in ironstone in the sand.

3. "On the Kessingland Cliff section, and the relation of the Forest-bed to the Chillesford Clay, with some remarks on the so-called terrestrial surface at the base of the Norwich Crag." By F. W. Harmer, Esq., F.G.S.

This paper was a reply to one read before the Society during last session by Mr. J. Gunn, F.G.S., who affirmed that the Forest-beds in the section were overlain by the Norwich Crag and Chillesford Clay. The author, on the contrary, gave, in the first part of the paper, detailed drawings of the cliff, in which he represented the fossiliferous deposits known as the Kessingland Beds as resting in a gorge cut out of, and consequently newer than, the Chillesford Clay. The beds present in the section, according to his view, are, in ascending order:—

1. The Chillesford Clay.

The Kessingland Beds

2. An unstratified blue clay, penetrated by rootlets, shown occasionally to be underlain by sand and gravel, which, with the clay, contains mammalian remains and freshwater shells.
3. A lenticularly-shaped bed of laminated clay and sand, with wood débris at its base.
4. The Middle Glacial sand and gravel.
5. The Upper Glacial or chalky Boulder-clay.

In the 2nd part of the paper the author urged that the stone bed at the base of the Norwich Crag, which contains marine shells and mammalian remains, was not an old land surface, as asserted by Mr. Gunn and others, but merely the basement-bed of the deposit which overlies it, the mammalian fossils it contains, which are principally worn and fragmentary portions of teeth, being derivative from some older Tertiary deposit, just as are the flints with which they are associated from the Chalk.

4. "Observations on the Geology of East Anglia, etc." By S. V. Wood, jun., Esq., F.G.S., and F. W. Harmer, Esq., F.G.S., etc.

The subjects discussed in this paper were threefold, viz.:—

1. The unfossiliferous sands of the Red Crag.
2. The unconformity between the Lower and Middle Glacial deposits.
3. The mode in which the Upper and Middle Glacial were accumulated.

The views of the authors under the first head were similar to and confirmatory of those advanced in the previous paper by Mr. Whitaker; but they pointed out that the Red Crag, which these sands, in an altered form, represent, could not belong to the Chillesford division of that formation, by reason of the casts of shells which had been preserved not comprising any of the more characteristic Chillesford species, and of their including among them forms confined to the older portions of the Red Crag. They also pointed out that the Chillesford Clay had been removed over all the area occupied by these sands by denudation prior to the deposition of the Middle Glacial, which rests upon these sands wherever they occur. The removal of the Chillesford Clay, the authors consider, was due in part, if not in all, to the great denudation between the Lower and Middle Glacial, which gave rise to the unconformity discussed under the second head.

This unconformity they illustrate by lines of section traversing most of the river valleys of Central and East Norfolk and Suffolk. These show that such valleys were excavated after the deposit of the Contorted Drift, and out of that formation and the beds underlying it. They also show that the Middle and Upper Glacial have been bedded into these valleys, as well as spread (the middle only partially, but the upper more uniformly) over the high grounds formed of Contorted Drift out of which they were excavated, and thus generally concealing that deposit, which manifests itself only in the form of occasional protrusions through these later formations, but which they consider constitutes, though thus concealed, the main mass of the two counties.

The authors also describe a glacial bed as occurring at various localities in the bottom of some of these valleys, and which in one case they have traced under the Middle Glacial. This they regard as having been formed in the interval between the denudation of the valleys and their subsequent submergence beneath the Middle Glacial sea; and inasmuch as such valley-bed invariably rests on the Chalk in a highly glaciated condition, they attribute its formation more probably than otherwise to the action of glaciers occupying the valleys during an interglacial interval of dry land. They also suggest that if this was so, it is probable that the forest and mammaliferous bed of Kessingland, instead of being coëval with the pre-glacial one of the Cromer coast, may belong to this interglacial interval—that is to say, to the earliest part of it, before the glaciers accumulated in the valleys, and when the climate was more temperate, any similar deposits in these interglacial valleys having been for the most part subsequently ploughed out by the action of the glaciers.

In discussing the subject under the third head the authors point out the many perplexing features which are connected with the position and distribution of the Middle Glacial formation; and while they admit that as to one or two of these the theory which they offer affords no explanation, they suggest that the theory of this formation's origin which best meets the case is as follows, viz.:—As the country became resubmerged, and as the valley glaciers retreated before the advancing sea, the land-ice of the mountain districts of North Britain accumulated and descended into the low grounds, so that by the time East Anglia had become resubmerged to the extent of between 300 and 400 feet, one branch of this ice had reached the borders of the counties of Norfolk, Suffolk, Essex, Herts, and Bedford, ploughing out and destroying any Lower Glacial beds that had been deposited over the intervening counties upon which it rested, and over which we ought otherwise, having regard to the depth of the earlier submergence under which they were accumulated, to find them, but do not. The Middle Glacial formation, consisting of sand and gravel, they attribute principally to the action of currents washing out and distributing the morainic material, which was extruded on the sea-bottom by this land-ice; that ice itself by keeping out the sea over all the country on which it rested, which was then below the sea-level, preventing the deposit of the Middle Glacial in those parts. The termination of this current action was accompanied by increased submergence, and by a gradual retreat of the land-ice northwards to the mountain districts, until Britain was left in the condition of a snow-capped archipelago, from which eventually the snow disappeared and the land emerged. To the moraine extruded from the base of this ice and into deep water they refer the origin of the Upper Glacial Clay, the moraine material remaining partly in the position in which the ice left it, and partly lifted by the bergs which became detached from the ice. Such part of it as was lifted was dropped over the sea-bottom at no great distance from its point of extrusion, and in that way the marine shells occurring in a seam of sand in the midst of this clay at Dimlington and Bridlington on the Yorkshire coast became imbedded, the mollusca which had established themselves on the surface of this moraine material having been thus smothered under a lifted mass of the same, which was dropped from a berg. The authors point out that precisely in the same way in which the Middle Glacial is found stretching out southwards and eastwards beyond the Upper Glacial Clay in Suffolk and in Herts, and is succeeded by such clay both vertically and horizontally, so does the earlier formed part of the Upper Glacial Clay, or that with chalk débris, stretch southwards beyond the later formed part, or that destitute of such débris, and is succeeded by it, both vertically and horizontally. This, they consider, shows that the Middle and Upper Glacial deposits, which constitute an unbroken succession, were due to the gradually receding position of the land-ice during their accumulation, the sequence being terminated with the Moel Tryfaen and Macclesfield gravels, which were accumulated during the disconnexion and gradual disappearance of the ice, and while the land still continued deeply submerged.

CORRESPONDENCE.

INTERNATIONAL GEOLOGICAL CONGRESS.

Sir,—The activity which has prevailed in the study of geology within the past generation has given to it a great importance both in a scientific and an economic point of view, and has resulted in a large accumulation of facts and materials. Workers in different countries have however pursued their labours to a great extent independently of each other, and have given their results in such ways that it is often difficult to co-ordinate them. Those geologists from Europe and America who have been at the International Exhibition at Philadelphia in 1876, have found there important collections of geological maps and sections, with rocks and organic remains from various regions of North and South America, as well as from many countries of Europe, and they have become deeply impressed with the great advantages to be gained by their comparative study. It was moreover evident that the bringing together of a still larger number of such collections in accordance with a previously arranged plan, could not fail to lead to important results for geological science. The International Exhibition to be held at Paris in 1878 will furnish such an occasion, and it is proposed to invite to that end governmental geological surveys, learned societies and private individuals throughout the world. to send to Paris such collections as will make the geological department of that exhibition as complete as possible.

In order to take advantage of the collections which may thus be brought together, it is moreover proposed to convoke an International Geological Congress, to be held at Paris at some time during the Exhibition of 1878, and to make that Congress an occasion for considering many disputed problems in Geology.

In accordance with this plan it is proposed that the Geological Department of the International Exhibition of 1878 shall embrace:

I. Collections of crystalline rocks, both crystalline schists and massive or eruptive rocks, including the so-called contact-formations and the results of the local alteration of uncrystalline sediments by eruptive masses. In this connexion are to be desired all examples of organic remains found in crystalline rocks, including Eozoon and related forms. These collections should moreover comprehend all rare and unusual rocks of special lithological, mineralogical and chemical interest, examples of ore-deposits and of veinstones of all kinds, with their encasing rocks. As far as possible these collections should be limited to specimens of a size convenient for examination, and be accompanied with sections prepared for microscopic study. In the arrangement of all these materials regard should be had to their natural associations rather than to theoretical notions or artificial classifications, so that they may be studied not only petrographically but geognostically.

II. Collections illustrating the fauna and the flora of the Palæozoic and more recent periods, particularly of such horizons as present a more critical interest to palæontologists from the first appearance or the disappearance of important groups of organic forms. It has appeared to the Committee named below that the organic remains of the Cambrian, Taconic or so-called Primordial strata merit especial attention in this connexion.

These various collections should be explained as fully as possible by labels, catalogues, monographs and maps.

III. Collections of geological maps, and also of sections and models, especially such as serve to illustrate the laws of mountain structure. In the geological maps regard should be had to various questions which deserve the special consideration of the Congress, such as the scales best adapted for different purposes, the colours and symbols to be used, and the proper mode of representing superficial deposits conjointly with the underlying formations. A discussion of these will prepare the way for improved general geological maps of the continents.

In pursuance of the above plan, the American Association for the Advancement of Science during its annual meeting at Buffalo, under the presidence of Prof. William B. Rogers, unanimously adopted the following resolution on the 25th of August, 1876:—

"*Resolved*, That a Committee of the Association be appointed by the Chair to consider the propriety of holding an International Congress of Geologists at Paris, during the International Exhibition in 1878, for the purpose of getting together comparative collections, maps and sections, and for the settling of many obscure points relating to geological classification and nomenclature. And that to this Committee be added our guests, Prof. T. H. Huxley of England, Dr. Otto Torell of Sweden, and Dr. E. H. von Baumhauer of the Netherlands, who shall be requested to open negociations in Europe, looking to a full representation of European geologists at the proposed Congress. The said Committee to consist of Prof. William B. Rogers, Messrs. James Hall, J. W. Dawson, J. S. Newberry, T. Sterry Hunt, C. H. Hitchcock, and R. Pumpelly in behalf of the Association, with the addition of Prof. T. H. Huxley, Dr. Otto Torell, and Dr. E. H. von Baumhauer."

On the same day, at a meeting of the Committee, Prof. James Hall was elected Chairman, and Dr. T. Sterry Hunt, Secretary. It was then resolved to prepare the present circular, to be printed in English, French, and German, and distributed to geologists throughout the world, asking their co-operation in this great work of an International Geological Exhibition and an International Geological Congress to be held at Paris in 1878; the precise date of the Congress to be subsequently fixed.

All those interested in this project are invited to communicate with any one of the following members of the Committee:—

Prof. T. H. Huxley, London, England.
Dr. Otto Torell, Stockholm, Sweden.
Dr. E. H. von Baumhauer, Harlem, Holland.
Dr. T. Sterry Hunt, Boston, Mass., U.S.A.

Philadelphia, U.S.A., T. STERRY HUNT, *Secretary.*
Oct. 27th, 1876.

NEW BRITISH BRACHIOPODA.

Sir,—During a recent visit to Abbotsbury, Dorsetshire, I obtained from the Upper Corallian red ferruginous rock some specimens of *Terebratula subsella*, Leymerie. I think this species has not been discovered in England before. The other Brachiopoda which occur in this rock are:—*Waldheimia lampas*, Sow., *Waldheimia Dorsetensis*, n.sp., *Rhynchonella pinguis*, Roemer, = *Rhyn. corallina*, Leym. These species will be figured in Mr. Davidson's Jurassic Supplement.

J. F. Walker.

DEVONIAN AND OLD RED SANDSTONE.

SIR,—I wish to call attention to what Mr. Horace Woodward, in his interesting "Geology of England and Wales," says on the above subject. At page 72 of Mr. Woodward's book, and paragraph at the foot of the page, beginning "Mr. Etheridge places these limestones," etc., the reader will notice two principal points: first, the probable conformability of the Culm-measures on the Devonian Limestones, and secondly that the Cockington beds, "similar in character to Old Red Sandstone," are beneath the Limestones.

Sir H. de la Beche questioned this last point (see page 72 of the "Report"), . . . "And it becomes difficult to determine whether these Sandstones are higher in the series than the Torquay and Tormoham Limestones, or whether we may consider them represented by the Red Sandstones occurring amid the beds inferior to the Limestones which extend from Meadfoot Sands to Upham." Dr. Holl went further, and pronounced them higher than the Berry Park Slates, and these in their turn higher than the Limestone.

Assuming, however, that the Cockington beds are the same as the red beds forming the heart of the Torquay peninsula (and the Torquay geologists do not appear to be troubled with a doubt on this score), I will venture to add a rider to Mr. Woodward's paragraph, viz., that "Upper South Devon Slates" *are a fiction.* For the Cockington beds, being older than the limestone, will become inverted as they range westwards by Beacon Hill, having the Wildwood and Berry Park Slates conformably between them and the Limestones, and standing in the place of the main mass of Lower Slates.

In Dr. Holl's hypothetical section of the inversions of the Kingsbridge promontory (page 438 of his Memoir, Q. J. G. S., 1868), as I read it, to whatever dimensions the supposed Upper Slates may swell out, he yet conceives the Red Grit Group (*d*) to be higher still. May the Slates be the Lower Slates, and the Red Grit Group *lower* still?

Before we need work out details and draw boundary-lines, it is manifestly of the utmost importance that we should read our sections aright. The Plymouth Limestone might thus occupy an inclined trough, and we should be relieved from the supposition of such a rapid thinning out as must be the case if it be intercalated between two slate groups. The Sharkham Point Limestone would be similarly circumstanced, its southern outcrop being inverted.

Speaking, then, in very general terms, grey colours and slaty rocks would mantle round red grit areas, and on the other hand they would surround and support lines or oases of limestone, these being frequently doubled on themselves and rarely showing their true summit.[1] The Limestone is occasionally brought into abrupt contact with the red beds by faulting, as at Kent's Cavern Coppice on the north side of the Lincombe Hill.

From my study of the country it appears to me a necessary consequence of the Cockington red beds being beneath the Limestones that there are no upper slates. But this obviously follows if the conformability of the Culm-measures and the Limestones be admitted, as the Culm-measures at Ogwell and the Berry Park Slates at Loventor cannot both be conformable on the Great Devon Limestone; and this is tantamount to allowing that the slates are beneath.

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[1] Perhaps among the highest of the series may be the thin-bedded Red Clymenia Limestone of Lower Dunscombe, near Chudleigh.

Dr. Holl says truly that the organic remains of the Upper Slates of Berry immediately above the Limestones do not appear to differ from those beneath them. This is so far in favour of their being one and the same thing.

Let me close, however, with saying that until within the last month, I held, in spite of many perplexities, the same views with Dr. Holl, but since the appearance of Mr. Woodward's book, I quite think that he has found the clue to unravel the country.

DARTINGTON HALL, *October 31st*, 1876. A. CHAMPERNOWNE.

HARPACTIRA v. *HARPACTES.*

SIR,—Finding that the generic term *Harpactes* has been appropriated by the Ornithologists, I beg leave to substitute *Harpactira* for the fossil fish described in the October Number of this MAGAZINE (p. 441). PHILIP GREY EGERTON.

FURTHER LOCALITIES FOR *ACANTHOSPONGIA SMITHII*, YOUNG, AND *ESTHERIA DAWSONI*, JONES.

SIR,—Will you allow me to give one or two further localities for this interesting Carboniferous fossil, described by Mr. J. Young at the late meeting of the British Association in Glasgow. A number of the spicules of *Acanthospongia Smithii* (see Armstrong, Young, and Robertson's Cat. W. Scottish Fossils, 1876, p. 38) have been presented to the Survey Collection by Mr. Smith, who first discovered the fossil, through Mr. J. Bennie, from the typical locality, Cunninghame Bealand, near Dalry, Ayrshire. With the aid of these specimens I am enabled to state that it occurs in the No. 1 Limestone of the Calderwood Series (Lower Carboniferous Limestone Group) at East Drumloch Quarry, near East Kilbride, Lanarkshire; again in limestone in the railway cutting at Waterland, Lugton Inn, near Dunlop, Ayrshire; and lastly in the east of Scotland at one of the Currielee Quarries, Tyne Water, near Borthwick, Edinburghshire.

When collecting in the neighbourhood of Dunbar within the last month, Mr. J. Bennie hit upon a bed of shale in the Red Sandstone, or Lower Group of the Calciferous Sandstone Series, at the base of the Carboniferous system in the East of Scotland, containing peculiar plant remains, a number of modioliform bivalves, and an *Estheria*, which Prof. T. Rupert Jones, F.R.S., tells me is scarcely, if at all, to be distinguished from the Nova-Scotian Lower Carboniferous form *E. Dawsoni*, Jones. R. ETHERIDGE, Jun.

EDINBURGH.

MR. J. F. WHITEAVES, F.G.S., formerly of Oxford, England, who for thirteen years has held the post of Scientific Curator and Secretary to the Natural History Society of Montreal, has been recently appointed Palæontologist to the Geological Survey of Canada, vacant by the death of Mr. E. Billings, F.G.S.

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